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Geology of the Lingman Lake Area District of Kenora (Patricia Portion)

by
B.C. Wilson

1987

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Frontispiece. *Mine dump and shaft (at centre of photograph) of Twin Gold Mines Limited, Lingman Lake, Ontario.*

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FOREWORD

Nearly half a century after its discovery in the Lingman Lake belt, gold is once again a much sought commodity. This report and the accompanying map were commissioned in 1981 to re-evaluate the mineral potential and update the geological data base of this remote area. I hope that the information contained herein will stimulate mineral exploration interest in this often ignored part of Ontario.

V.G. Milne
Director
Ontario Geological Survey

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GEOLOGICAL MAP (back pocket)

Map 2511 (coloured)—Lingman Lake Area, District of Kenora (Patricia Portion).

Scale 1:50 000.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

ERRATA

The following local names are now known officially as:

Local Name	Official Name
P. S. Lake	Manikoman Lake
Tequila Lake	Etamame Lake
Wigwan Lake	Matikwan Lake

Geology of the Lingman Lake Area District of Kenora (Patricia Portion)

by
B.C. Wilson

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ABSTRACT

The Lingman Lake area is dominated by metavolcanics comprising predominantly mafic flows and derived clastic rocks interlayered with at least 3 minor sequences of felsic and intermediate to felsic flows and pyroclastic rocks, interlayered with and, in part, transitional to the metavolcanics are metasediments which consist of arenite, wacke, mudstone, and conglomerate. Very minor volumes of chemical metasediments, including chert, magnetite ironstone, and iron silicate rocks, are interdigitated with the metavolcanics throughout the map area.

The supracrustal rocks are surrounded by, and close to the edges of the greenstone belt, intruded by tonalite, granodiorite, and granite. Both the supracrustal and granitic rocks are intruded by quartz gabbro and feldspar porphyry. Other intermediate to felsic intrusive rocks which crosscut the supracrustal sequence include quartz-feldspar porphyry, quartz porphyry, and feldspar-quartz porphyry. Pyroxenite occurring in the southeastern part of the map area may be intrusive or extrusive in origin.

The supracrustal rocks have been folded into a major anticline and 2 flanking synclines. On the limbs of these folds, rock units are deformed by "S" and "Z" shaped minor folds and by corresponding axial planar "fracture" cleavages. Rocks at the centre of the belt are of low-temperature, low-grade metamorphic rank whereas those at the edges of the belt are generally of medium-grade. When folding was completed, Proterzoic diabase dikes crosscut all other rock types.

After the diabase dikes had cooled, all of the map area was deformed by near-vertical, strike-slip faults. Hydrothermal fluids moving along faults produced alteration dominated by silicification, and resulted in the deposition of sulphide minerals consisting mainly of pyrite but including arsenopyrite, chalcopyrite, galena, and pyrrhotite. Molybdenite, silver, and gold, minerals not necessarily related to faulting, are also found in the Lingman Lake area. A gold deposit on which there has been considerable underground development was discovered 1.5 km north of the west end of Lingman Lake in 1942.

Geology of the Lingman Lake Area, District of Kenora (Patricia Portion), by B.C. Wilson, Ontario Geological Report 244, 42p. Accompanied by Map 2511, Scale 1:50 000. Published 1987. ISBN 0-7729-1038-3.

Résumé

Dans la région du lac Lingman dominent des formations métavolcaniques composées essentiellement de coulées matiques et de roches clastiques dérivées entrecoupées d'au moins trois séries mineures de coulées felsiques et intermédiaires à felsiques et de roches pyroclastiques. Des roches métavolcaniques sont intercalées et forment une transition partielle avec des roches métasédimentaires composées d'arénite, de wacke, de pélite et de conglomérat. De très petits volumes de roches métasédimentaires chimiques, comprenant du chert, du minerai de fer magnétite et des silicates de fer, sont intercalées entre les roches métavolcaniques dans l'ensemble de la région représentée par la carte.

Les roches supracrustales sont proches des bords de la ceinture de roches vertes qui les cerne et qui comprend des intrusions de tonalite, de granodiorite et de granit. On trouve des intrusions de gabbro quartzique et de porphyre feldspathique dans les roches en surface de l'écorce terrestre et les roches granitiques. D'autres roches intrusives intermédiaires à felsiques qui entrecoupent la série supracrutale comprennent du porphyre, du feldspath et du quartz, du porphyre et du quartz, et du pyroxénite présents dans la partie sud-est de la région représentée par la carte peuvent avoir une origine intrusive ou extrusive.

Les roches supracrustales ont été plissées en deux anticlinaux majeurs et deux synclinaux latéraux. Sur les flancs de ces plis, les unités rocheuses sont déformées par des plis mineurs en forme de "S" et de "Z" et par des clivages, plans de "fracture" axiaux correspondants. Les roches situées au centre de la ceinture ont une température basse et un faible degré de métamorphisme, alors que celles du bord ont habituellement un degré moyen de métamorphisme. Après la formation du pli, des dykes de diabase de l'ère protérozoïque ont recoupé tous les autres types de roches.

Après le refroidissement des dykes de diabase, l'ensemble de la région représentée par la carte a été déformée par des failles proches de la verticale et présentant un glissement de direction. Des fluides hydrothermaux s'écoulant le long des failles ont produit des altératins dominées par la silicification et se traduisant par des dépôts de minéraux sulfurés composés essentiellement de pyrite mais comprenant la pyrrhotine. On trouve également, dans la région du lac Lingman, molybdénite, de l'argent et de l'or, ces minéraux ne sont pas forcément liés à la formation des failles. En 1942, on a découvert, à 1,5 km au nord de l'extrémité ouest du lac Lingman, un gisement aurifère qui a donné lieu à un grand nombre d'explorations souterraines.

INTRODUCTION

Location and Access

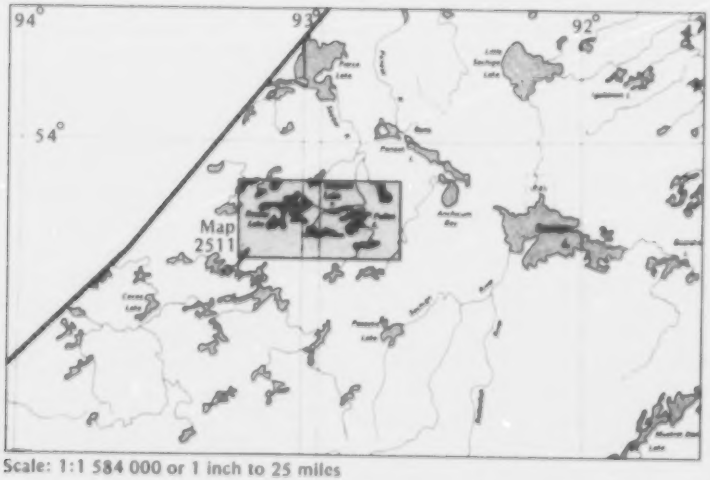
The Lingman Lake greenstone belt, an irregularly shaped complex of Archean metavolcanics, metasediments, and intrusive rocks, is approximately bounded by 53°45'N and 53°55'N Latitudes and 92°40'W and 93°15'W Longitudes, and is centred about 325 km north of Red Lake. The map area is best reached by float-equipped or ski-equipped aircraft available for charter at Red Lake or Pickle Lake. A winter road from Red Sucker Lake and Island Lake, Manitoba crosses the central part of the map area.

All of the lakes except Tequila Lake are shallow, and care must be exercised when choosing landing sites for aircraft or when operating outboard motor boats. Small boats, especially light canoes, allow travel throughout the map area. However, because of numerous rapids, not all of which are shown on the map, the repeated use of interconnecting waterways is often impractical. Rough portages have been cut and, in the 1981 field season, were used to facilitate travel from Durrel Lake to Pullen Lake by way of P.S. Lake, Lingman Lake, and Lawson Lake. During the field season, water levels on lakes and interconnecting waterways did not vary significantly.

Field Mapping Procedure

Geological mapping was carried out at a scale of 1:31 680 (1 inch to 1/2 mile). Geological data were plotted on acetate overlays on vertical, black and white air photographs supplied by the Department of Energy, Mines and Resources, Canada. The base map at the same scale was prepared by the Cartography Section, Surveys and Mapping Branch, Division of Lands and Waters, Ontario from 1:50 000 scale topographic maps N.T.S. 53 F/14 and 53 F/15 published by the Department of Energy, Mines and Resources, Canada. The base map was subsequently redrawn and modified by the author on the basis of the most recent airphoto coverage.

Traverses by pace-and-compass were run to visit bedrock outcrops located by examination of the air photographs. Due to the scale of mapping, only a fraction of the exposures were visited in some sections of the map area. South of Tequila Lake, pace-and-compass traverses were difficult because of recent burn and aeromagnetic anomalies. Picket lines and an unpublished map of Amoco Canada Petroleum Company Limited were used for control wherever possible in that area.



Scale: 1:1 584 000 or 1 inch to 25 miles

Figure 1. Key map showing the location of Lingman Lake Area.

but the locations of all outcrops shown to the south of Tequila Lake should be taken to be approximate.

Geological data found in the assessment records on file at the Assessment Files Research Office, Ontario Geological Survey, Toronto and at the Resident Geologist's Office, Ministry of Natural Resources, Red Lake, and data from unpublished maps of Amoco Canada Petroleum Company Limited were used to a limited extent in the mapping and interpretation of the Lingman Lake area. The present study concentrated on the supracrustal rocks (see Discussion and Synthesis, below) of the map area and did not involve detailed examinations of the surrounding granitic rocks or the unconsolidated Pleistocene and Recent sediments.

Physiography

Bedrock outcrops are abundant in most parts of the map area but are widely scattered or absent between P.S. Lake and Lingman Lake, between Durrel Lake and Pullen Lake, and along the north shores of most of the lakes. Outcrop surfaces are commonly lichen-covered but are only rarely moss-covered, providing excellent weathered surfaces for the study. Much of the area has, at 1 time or another in the recent past, been burnt by forest fires. In most places, the result is easier access and better exposures.

The map area is forested with stands of spruce, jack pine, birch, and poplar, very little of which is suitable for lumber. Alder swamps commonly border streams, rivers, and many lakes, and peat-flats dotted with small spruce are found throughout the map area. Local relief rarely exceeds 20 m in a predominantly gently rolling terrain. Maximum relief in the Lingman Lake area is 40 m. Drainage is commonly good in the vicinity of the supracrustal rocks, but is poor in the surrounding region. There are numerous small, mostly interconnected shallow lakes, all of which drain into Lingman Lake which empties, in turn, through the Seeber River at the northeast corner of the area.

Previous Mapping

Most of the Lingman Lake area was first mapped in 1936 by O.A. Seeber and G.M. Robson, assistants to J. Satterly (1938). More recently, the entire map area was surveyed by G. Bennett and R.A. Riley (1969) in 1967 as part of a much larger mapping project, Operation Lingman Lake. Relevant geological data were presented on 2 preliminary maps (Bennett and Riley 1967a; 1967b) at a scale of 1:126 720 (1 inch to 2 miles) and a coloured compilation map (Bennett *et al.* 1969) at a scale of 1:253 440 (1 inch to 4 miles). Important differences between the study of Bennett and Riley and the present study are discussed below (see Discussion and Synthesis). Parts of the Lingman Lake map area appear on company maps submitted to the Ontario Geological Survey for assessment credit (see Table 2).

The Lingman Lake area is also on published topographic (Department of Energy, Mines and Resources, Canada, 1977a, 1977b) and aeromagnetic maps (Department of Mines and Natural Resources, Manitoba *et al.* 1966; Ontario Department of Mines-Geological Survey of Canada 1966) and unpublished geophysical maps submitted by companies (see Table 2) for assessment credit.

Claim maps for the Lingman Lake supracrustal belt comprise Vanderbrink Lake, plan number M2181; Seeber Lake, plan number M2179; North of Lingman Lake, plan number M2198; Lingman Lake, plan number M2064; and South of Ponask Lake, plan number M2027.

Mineral Exploration

Most of the Lingman Lake belt has been staked at 1 time or another. Old claim maps indicate an extremely complex history of staking and re-staking, beginning as early as 1938. Prospecting was first reported in the area in 1936 and exploration and staking have continued intermittently to the summer of 1981. Exploration was most intense after the discovery of gold in 1942. By 1946, at least 19 claim groups were held covering most of the northern half of the Lingman Lake belt. Reported

activity has centred around known gold occurrences just northwest of Lingman Lake and several sulphide mineral occurrences near Wigwam Lake. Patented and leased claims covered much of these 2 localities in September 1981.

The oldest assessment work on record consists of reports (see Table 2) on the gold property now held by Twin Gold Mines Limited (6) (originally Lingman Lake Mines Limited). In 1938 and 1939, prior to the acquisition of any claims by that company, this ground had been staked and geologically mapped. The ground was restaked and purchased by Lingman Lake Mines Limited, and in 1945 and 1946, at least 73 diamond-drill holes were collared on the surface. Between 1946 and 1949, a total of 1383 m of drifting, crosscutting and raising was completed from a 126 m deep shaft. Underground diamond drilling during that period totalled 1988 m from levels established at depths of 46, 84, and 122 m. In 1973, 4 diamond-drill holes, 1 of 302 m, were collared from the surface.

Gold exploration, including trenching, geophysical surveys, and diamond drilling, was carried out between 1945 and 1948 by Lingnora Gold Mines Limited, Lingside Gold Mines Limited (now Lingside Copper Mining Company Limited), Winora Gold Mines Limited (now Roman Corporation Limited), and Linkey Gold Mines Limited (Bennett and Riley 1969). Also reported (Thomson 1947) to be active in the area around 1946 and 1947 were Mining Corporation of Canada Limited and Teck-Hughes Gold Mines Limited (now Teck Corporation). Roman Corporation Limited (4) and Lingside Copper Mining Company Limited (3) held, in September 1981, patented claims adjacent to those held by Twin Gold Mines Limited.

Others interested in the area have included International Minerals and Chemical Corporation (Canada) Limited (1), active in 1966 and 1967, Effie Johnson, active in 1976, 1978, and 1979, Kennco Explorations (Canada) Limited (2), active in 1960, and, most recently, Amoco Canada Petroleum Company Limited, active in 1980 and 1981. Reports (Assessment Files Research Office, Ontario Geological Survey, Toronto) of work completed include results of diamond drilling, airborne magnetic and electromagnetic surveys, ground magnetic, electromagnetic and induced polarization surveys, and geological surveys.

As of September 1981, Silveroc Mines Limited (5) held 15 leased claims in the vicinity of Wigwam Lake and Amoco Canada Petroleum Company Limited held 107 claims adjacent to the claims held by Roman Coporation Limited and Lingside Copper Mining Company Limited. The only mineral exploration noted by the author during the 1981 field season was a very brief visit to the area by geologists from Canadian Occidental Petroleum Limited.

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General Geology

The Lingman Lake map area lies within the Gods Lake Belt (Ayres *et al.* 1971). Rock-types identified in the present project have been summarized in Table 1. The stratigraphy is characterized by a sequence of steeply dipping, interbedded layers of mafic, felsic, and intermediate to felsic metavolcanics and associated clastic and chemical metasediments.

The metavolcanics and metasediments are intruded by quartz gabbro, granodiorite, granite, feldspar and quartz-feldspar porphyry, quartz and feldspar-quartz porphyry, diabase, and possibly by pyroxenite, and are surrounded by tonalite, granodiorite, and granite. The supracrustal sequence was folded into a major anticline and 2 flanking synclines.

Mineral parageneses indicate relatively low-temperature, medium-grade metamorphism (Winkler 1976) around the edges of the greenstone belt and low-temperature, low-grade metamorphism in the central parts of the belt.

All of the rocks in the Lingman Lake area, including diabase dikes and the granitic rocks which surround the supracrustal belt, are cut by eastward to southeastward trending, near vertical, strike-slip faults, many of which have been channelways for mineralizing solutions. These solutions resulted in wall rock alteration dominated by silicification, uralitization, saussuritization, and carbonatization, and the deposition of sulphide minerals.

Precambrian rock-types mapped within the Lingman Lake area are subdivided as shown on Table 1. Metavolcanics were classified on the basis of colour index which refers to the percent of mafic, but not necessarily dark coloured minerals. Mafic metavolcanics and intrusive rocks have a colour index greater than 35 and intermediate to felsic metavolcanics have a colour index less than 35.

Consistent and accurate separation of rock-types is hindered by such variables as metamorphic grade, content of leucocratic ferromagnesian minerals, and degree of deformation and alteration. The transitional nature of the genesis and emplacement of many rock-types further complicates rock classification. At the present scale of mapping, contacts between thin rock units must be omitted and many sequences are necessarily generalized.

EARLY PRECAMBRIAN (ARCHEAN)

Metavolcanics and Metasediments

NOMENCLATURE Both mafic and intermediate to felsic pyroclastic rocks are interbedded with, and are transitional to, epiclastic rocks. Tuff, and arenite derived from tuff or flows can have identical mineralogies and are only distinguished by textural characteristics or primary depositional structures. No reliable criteria were established to separate these 2 rock-types, however, mica, probably derived from clay minerals, is generally associated with rocks of epiclastic origin.

In the Lingman Lake area, it was found that clastic rocks interbedded with, or in places stratigraphically equivalent to, mafic flows are predominantly dark green with only minor proportions of dark brown-green or dark grey-green clastics. Where they are massive, dark green clastic units may be impossible to distinguish from mafic flows. At the present scale of mapping, with the very close association of these 2 rock-types, all of the mafic clastics, whether tuff or arenite, have been mapped with the metavolcanics.

White to light brown, grey or green, massive, extra thickly bedded (greater than 3 m) felsic and intermediate to felsic tuff and crystal tuff are transitional to similar looking, light-coloured arenite and granule conglomerate. In this study, outcrops were mapped as felsic or intermediate to felsic tuff and crystal tuff where they contain predominantly extra thickly bedded, massive, white to light brown, grey or green, sand and granule-size clasts or where they contain abundant medium to dark grey feldspar-phyric lapilli. Outcrops were mapped as arenite and granule conglomerate where they contain thinly bedded to thickly bedded (10 to 100 cm) but commonly very thickly bedded (1 to 3 m), massive, light to medium brown, grey, or green, sand and granule-size clasts interbedded with a significant propor-

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE LINGMAN LAKE AREA.

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT
Till, sand, gravel, silt, clay

Unconformity

PRECAMBRIAN

MIDDLE OR LATE PRECAMBRIAN (PROTEROZOIC)

MAFIC INTRUSIVE ROCKS
Diabase, olivine diabase, porphyritic diabase

Intrusive Contact

EARLY PRECAMBRIAN (ARCHEAN)[a]

ULTRAMAFIC INTRUSIVE ROCKS
Serpenitized pyroxenite

Intrusive Contact[c]

MAFIC TO INTERMEDIATE INTRUSIVE ROCKS
Quartz gabbro, porphyritic quartz gabbro

Intrusive Contact

INTERMEDIATE TO FELSIC INTRUSIVE ROCKS
Granodiorite, and/or tonalite, and/or granite
Feldspar porphyry, quartz-feldspar porphyry
Quartz porphyry, feldspar-quartz porphyry

Intrusive Contact

METAVOLCANICS AND METASEDIMENTS

CHEMICAL METASEDIMENTS
Chert, magnetite ironstone, iron silicate rock

CLASTIC METASEDIMENTS
Arenite, granule conglomerate, wacke, mudstone, metavolcanics, micaceous wacke, quartz-granule conglomerate, granule to pebble conglomerate

INTERMEDIATE TO FELSIC METAVOLCANICS
Flows, tuff, crystal tuff, lapilli-tuff, minor metasediments including arenite, granule conglomerate, wacke, or mudstone.

MAFIC METAVOLCANICS
Massive flows, tuff, minor wacke, mudstone, or arenite, pillowed flows, feldspar porphyry flows, biotite-rich flow, altered mafic metavolcanics, bedded tuff.

Notes
a) These rocks are grouped lithologically and the order does not necessarily imply age relationships between groups.
b) The pyroxenites may have been emplaced as flows conformable with the metavolcanics and metasediments.

tion of thinly laminated to thinly bedded (less than 0.3 to 10 cm) wacke and mudstone.

For the purposes of this report, arenite is defined as a sandstone with less than 15 percent fine matrix; a wacke is composed of 15 to 75 percent fine matrix and a mudstone is composed of greater than 75 percent fine matrix. Fine matrix is considered to be material below 0.06 mm in size plus phylosilicates and other metamorphic minerals derived from such material. During metamorphism some components of fine-grained rocks recrystallize to form larger grains sizes, making the estimation of original grain sizes and grain distribution difficult.

Conglomerates are defined as containing more than 15 percent clasts greater than 2 mm in size. Granules range from 2 to 4 mm and pebbles range from 4 to 64 mm.

Tuff is defined as a pyroclastic rock composed of more than 67 percent ash-size particles which are less than 2 mm in size. Lapilli-tuff contains 33 to 67 percent lapilli-size fragments, 2 to 64 mm in size, in a matrix of ash-size particles. Crystal tuff contains relatively large crystals and crystal fragments of plagioclase or quartz in a fine-grained, ash-size matrix.

Mafic Metavolcanics

Massive Flows Massive, fine- and medium-grained, mafic flows show few primary structures but they are commonly weakly to moderately foliated. Interflow tuff or arenite units, generally less than 1 m thick, are commonly more highly foliated than adjacent flows. Where they are not, the clastic rocks are difficult to distinguish from flows. Flow boundaries, marked by either interflow clastic rocks or finer grained chilled margins, were only rarely observed which may suggest that many flows are thicker than the width of individual outcrops, in places a distance of 10 m or more. Intrusive equivalents of the massive mafic flows common elsewhere in sequences of Archean mafic rocks were not observed in the Lingman Lake area.

Fresh surfaces of the massive flows are dark green or, in medium-grained flows, mottled light and medium to dark green. Weathered surfaces are uniform or mottled medium and dark green to black. Thin sections reveal the presence of plagioclase and a mafic mineral, most commonly an amphibole, and minor epidote and opaque minerals. Hornblende is found in flows which lie close to the supracrustal-granitic rock contact but actinolite is found in flows in the central part of the greenstone belt. Mafic mineral content averages approximately 50 percent. Plagioclase crystals, commonly light green on fresh surfaces, are partly to completely altered to saussurite, a mixture of mainly sodic plagioclase, epidote, carbonate, and sericite. In 1 sample, very slightly altered plagioclase crystals were found to have an anorthite content of approximately 55 percent.

A thick massive mafic flow which extends along the south shore of P.S. Lake was found to contain, in thin section, 40 percent hornblende, 30 percent plagioclase, 30 percent biotite, and minor sphene, epidote, and quartz. Outcrops of this flow are easily distinguished by their dark green, highly irregular, knobby weathered surface and by the presence of abundant black biotite on fresh surfaces. The mineralogy of this flow is similar to that of quartz gabbro dikes

found to the north and south of Tequila Lake (see Quartz Gabbro and Porphyritic Quartz Gabbro, below). Although mapped as a flow, there is no evidence to preclude the possibility that this conformable biotite-rich unit is intrusive in origin.

Pillowed Flows Pillowed, fine-grained to very rarely medium-grained, mafic flows are found throughout the map area. Commonly they are moderately to strongly foliated. Pillow shape and packing relationships provide abundant stratigraphic top indicators, however, only unequivocal facing determinations are shown on the map. Where pillow rims are the same colour as pillow core and where pillows are highly deformed or covered by organic material, they may be indiscernible and it is possible that many units mapped as fine-grained, massive flows are instead pillowed.

Interbedded clastic rocks composed of either tuff or arenite are in units commonly less than 1 m thick, but ranging up to 15 m. As with the massive flows, interflow boundaries were observed in only a few places.

Pillows average approximately 25 by 50 cm but range up to 1.5 by 2 m. in size. Strained pillows commonly have length to width ratios much greater than 2. Pillow rims, averaging 1 cm in thickness, are generally, but not necessarily, darker in colour than pillow cores. Both cores and rims are commonly variolitic with up to 75 percent by volume of lighter green, spherical to flattened varioles. These average less than 2 mm in size, but range up to 1 by 3 cm. Less commonly, pillows are highly fractured with 1 set of fractures radial and 1 set roughly parallel to the pillow rim. In many locations, pillows contain large multiple or more commonly single cavities now filled with variable proportions of quartz and feldspar. These lava drain-away lenses, some of which exhibit a medium-grained equigranular (granitic) texture, are also visible in flows in which no pillow rims have been discerned. Similar quartz-feldspar material occurs as debris between pillows, generally with up to 50 percent small angular fragments of mafic material. In most flows, the feldspar in lava drain-away lenses and interpillow debris is saussuritized producing medium yellow-green weathered surfaces.

Pillowed mafic flows are similar in colour and mineralogy to massive mafic flows described above.

Feldspar Porphyry Flows Weakly to moderately foliated, massive and pillowed mafic feldspar-phyric flows occur north of Lingman, Seeber, and Durrel Lakes and west of Durrel Lake. Roughly equant, double terminated crystals averaging 1.5 by 2 cm are found in massive flows near the northern edge of the supracrustal belt and in pillowed flows 1.5 km north of the west end of Durrel Lake. Large, tabular grains which commonly occur in pairs separated by matrix or joined across the centre to form an ""H'' (Photo 1) are present in mafic flows near the shaft on the Twin Gold Mines Limited property and along strike to the east. East of the shaft, a feldspar-phyric flow contains mostly equant crystals but in the top 10 to 20 cm it also contains tabular feldspar aligned parallel to the flow contact. This flow is covered by a discontinuous, 5 to 30 cm thick bed of chert, 4 cm of mafic clastic rocks, and 20 cm of pebble conglomerate in which the pebbles are rounded crystals of feldspar. Top directions determined from grading in the metasediments are to the north. Overlying the metasediments is another feldspar porphyry flow. The total thickness of feldspar-phyric flows in this area is at least 50 m.

Feldspar porphyry flows containing much smaller plates of feldspar are found west of Durrel Lake. There, however, the feldspar porphyry is, in part, intrusive into other metavolcanics.

Apart from their phenocryst populations, the porphyritic flows are similar in colour and mineralogy to the massive mafic flows described above.

Bedded Tuff Thinly laminated to thinly bedded (less than 0.3 to 70 cm) or rarely medium-bedded (10 to 30 cm) fine-grained clastic rocks which are commonly moderately to strongly foliated are found interbedded with massive or pillowed mafic flows in sequences averaging less than 3 m thick. Similar clastic units in

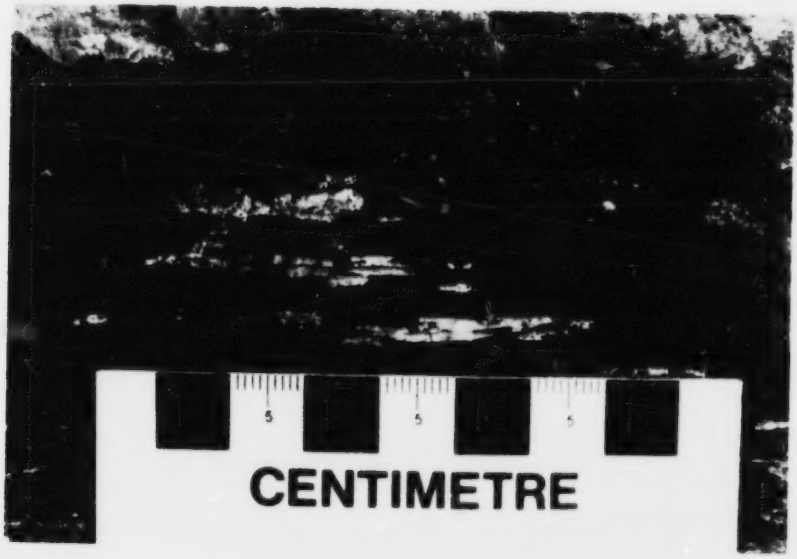

Photo 1. *Feldspar crystals in a porphyritic mafic flow on the Twin Gold Mines Limited property. Taken approximately 50 m west of the shaft.*

sequences tens to hundreds of metres thick near Seeber and Durrel Lakes are interbedded with minor volumes of mafic flows and appear to be stratigraphically equivalent to mafic flows along strike.

Weathered surfaces commonly, but not necessarily, show colour variation in white, black, and dark green and, more rarely, dark brown-green and dark grey-green, indicative of compositional banding. Fresh surfaces are relatively uniform in colour and are mainly dark green. Thin sections show variable proportions of an amphibole and plagioclase with minor volumes of biotite, sphene and leucoxene, epidote, and opaque minerals. Hornblende predominates in clastic rocks close to the supracrustal-granitic rock contact whereas actinolite is more common in the central part of the belt. White and green weathering bands are composed of predominantly plagioclase and amphibole respectively and are virtually biotite-free. Brown-green and grey-green layers contain up to 10 percent biotite.

Where primary structures are not discernible, these mafic clastic rocks are difficult to distinguish from fine-grained, massive mafic flows. Consequently, it is probable that many outcrops mapped as fine-grained flows are, in fact, composed of clastic material.

Intermediate to Felsic Metavolcanics

Flows, Tuff, Crystal Tuff, Lapilli-Tuff At the southeast end of Seeber Lake, massive, unfoliated, very fine grained feldspar and quartz-phyric felsic metavolcanics are found on 4 small islands and the nearby shore. These rocks, interpreted here to be flows, show no primary structures. Fresh and weathered surfaces are white to light brown and green or rarely medium green. Weathered surfaces commonly show slightly lighter shades than fresh surfaces. A single thin section examined contains 5 percent plagioclase and less than 1 percent quartz phenocrysts up to 1 mm in size in a very fine grained matrix composed of 90 percent plagioclase and quartz and 5 percent epidote. Plagioclase phenocrysts enclose relatively coarse-grained epidote and carbonate.

To the west and northeast of the flows are massive, extra thickly bedded (greater than 3 m) felsic tuff and feldspar and quartz-feldspar crystal tuff interbed-

ded with minor amounts of arenite, granule conglomerate, wacke and mudstone. These tuffs and crystal tuffs are white to light brown, green, and rarely grey on fresh and weathered surfaces, with slightly darker shades on fresh surfaces. A thin section from a sample found near the flows has the same mineralogy as the flows, but with the addition of 15 percent sericite and very minor tourmaline. Another thin section from a sample farther from the flows contains 15 percent plagioclase and 10 percent quartz clasts up to 2 mm in size in a very fine grained matrix composed of 45 percent plagioclase and quartz, 30 percent sericite, 1 percent sphene and opaque minerals, and very minor epidote. Also in this sample are 1 percent lithic clasts interpreted to be mudstone.

Intermediate to felsic metavolcanics at the south end of P.S. Lake are mainly very thinly bedded to medium-bedded (1 to 30 cm), moderately foliated lapilli-tuff and lesser tuff and feldspar crystal tuff interbedded with minor arenite, granule conglomerate, wacke, and mudstone. The pyroclastic rocks are light to medium grey on weathered surfaces and medium to dark grey on fresh surfaces. Lapilli, mostly feldspar porphyry or feldspar crystal tuff, are lighter in colour than the surrounding matrix which is composed of tuff or feldspar crystal tuff. On dark, fresh surfaces, the lapilli are typically indiscernible. A small percentage of lapilli observed on outcrop surfaces appears to be composed of fine-grained, massive intermediate to felsic tuff or flow material. A very small percentage is mafic in composition. Most lapilli are well rounded and lensoid in shape, however, a few lapilli and rare blocks (greater than 64 mm in size) are angular and roughly equant in shape. A thin section of crystal tuff contains 5 percent plagioclase and less than 1 percent quartz grains up to 2 mm in size in a very fine grained matrix composed of 75 percent plagioclase and quartz, 10 percent biotite, 5 percent epidote, and 5 percent carbonate. Along strike to the east, outcrops of lapilli-tuff contain a much higher proportion of dark green or dark grey tuff and feldspar crystal tuff. Petrographically, these rocks have the same mineralogy as rocks at the south end of P.S. Lake but with the addition of 10 percent chlorite and 5 percent sphene and leucoxene.

South of Tequila Lake, the felsic metavolcanics are predominantly massive, weakly to moderately foliated, white to light brown weathering quartz-phyric rocks. Typically, their fresh surfaces are white. Although field relationships and textures suggest that some of these metavolcanics are clastic rocks, most may be flows. The felsic rocks are intimately interbedded and transitional with arenite, wacke, and mudstone and, on a larger scale, they interdigitate with mafic metavolcanics and chemical metasediments.

A thin section of a tuffaceous material from this area contains 5 percent plagioclase and 2 percent quartz clasts up to 1 mm in size in a very fine grained matrix composed of 80 percent plagioclase and quartz, 10 percent sericite, 1 percent biotite, 1 percent opaque minerals, 1 percent sphene and leucoxene, and very minor almandine garnet, tourmaline, and epidote. A massive sample consists of 10 percent polycrystalline quartz aggregates up to 1 by 2 mm in size in a very fine grained matrix composed of 87 percent plagioclase and quartz, 3 percent sericite, and very minor sphene and leucoxene, epidote, and opaque minerals.

Northwest of Tequila Lake are well-bedded, moderately foliated intermediate to felsic metavolcanics very similar to those found at the south end of P.S. Lake. A thin section of crystal tuff includes 10 percent plagioclase and 3 percent quartz clasts up to 2 mm in size in a very fine grained matrix composed of 75 percent plagioclase and quartz, 5 percent biotite, 4 percent sphene and leucoxene, 2 percent epidote, 1 percent opaque minerals, and very minor chlorite and carbonate.

Clastic Metasediments

Arenite—Granule Conglomerate Association Outcrops of massive, moderately foliated, thinly to very thickly bedded (10 cm to 3 m) arenite and granule conglomerate interbedded with as much as 50 percent wacke and mudstone are present west and northeast of the felsic flows at Seeber Lake and along the shores of Lingman Lake. The arenite and granule conglomerate are believed to be transitional to intermediate to felsic tuff and crystal tuff at Seeber Lake.

Where they are exposed, weathered surfaces are light to medium brown, grey, or green. Fresh surfaces are darker and appear somewhat less siliceous than fresh samples of tuff and crystal tuff. Thin sections of arenite and granule conglomerate comprise variable proportions of plagioclase and quartz clasts up to 1 mm in a fine-grained matrix of plagioclase and quartz, up to 15 percent biotite, up to 13 percent sericite, minor epidote, sphene, leucoxene, and opaque minerals, and very minor tourmaline.

Wacke-Mudstone Association Thinly laminated to thinly bedded (less than 0.3 to 10 cm), moderately to very strongly foliated wacke and mudstone are found at Tequila Lake, across Lingman Lake and P.S. Lake, and across the centre of Seeber Lake. Interbedded with the wacke and mudstone are minor proportions of the arenite or granule conglomerate described above, or units of dark green, brown-green or grey-green mafic tuff or arenite (see section "Bedded Tuff"). More commonly, however, the wacke and mudstone are interbedded with quartz-granule conglomerate. This conglomerate, found with wacke-mudstone matrices, predominates in some sequences.

Across Lingman and Seeber Lakes and P.S. Lake, the wacke and mudstone, and to a lesser extent the quartz-granule conglomerate, show 1, or rarely 2 sets of cleavage which are commonly oblique to bedding (see Structural Geology). Mudstones commonly show a slaty, more penetrative cleavage which approximately parallels bedding.

Weathered surfaces of wacke are medium to dark grey or brown and fresh surfaces are dark grey or brown. Weathered and fresh surfaces of mudstone are black, commonly with a glossy sheen from mica-covered cleavage surfaces. Thin sections of wacke and mudstone contain highly variable proportions of fine to very fine grained plagioclase, quartz, biotite, sericite, chlorite, epidote, sphene and leucoxene, amphiboles including hornblende and actinolite, opaque minerals, and tourmaline. Garnet, chloritoid, and andalusite are found on the north shore and east of Tequila Lake, on the south shore of Durrel Lake, and close to the greenstone-granitic rock contact in the southeastern part of Seeber Lake. A thin section of quartz-granule conglomerate contains 25 percent quartz, 1 percent plagioclase and 1 percent lithic clasts up to 2 mm in size in a very fine grained matrix consisting of 47 percent quartz and plagioclase, 10 percent biotite, 15 percent chlorite, 2 percent sericite, and 1 percent opaque minerals. From outcrop observation, this quartz-granule conglomerate also contains approximately 5 percent granule- to pebble-size clasts of mudstone and arenite.

Micaceous Metasediments Thinly laminated to thinly bedded (less than 0.3 to 10 cm), commonly moderately to strongly foliated micaceous wacke, mudstone, and quartz-granule conglomerate occur east of Tequila Lake, at the east end of Lingman Lake, and across the central part of Seeber Lake. These rocks were differentiated in the field from similar wacke, mudstone, and conglomerate rocks with which they are transitional on the basis of abundant coarse mica easily visible in hand specimen. Like the less micaceous varieties, mica-rich wacke, mudstone, and granule conglomerate show 1 or 2 cleavages oblique to bedding, and micaceous mudstones show a slaty but more uneven cleavage characteristic of a schist.

Weathered surfaces are medium to dark grey or brown, commonly streaked with black, biotite-rich layers. Fresh surfaces are dark grey or brown. Thin sections show mineralogy which is similar to the less micaceous varieties of wacke, mudstone, and quartz-granule conglomerate described above.

Conglomerate Moderately foliated pebble or interbedded pebble and granule polymictic conglomerates were found in only a few areas, all on the shores of Seeber Lake. In the southeastern part of Seeber Lake, a well-exposed, matrix- to clast-supported pebble conglomerate consists predominantly of light to medium green metavolcanic clasts and minor white quartz clasts in a dark green matrix

composed of mafic tuff or arenite (see section "Bedded Tuff"). Metavolcanic clasts are strongly flattened.

On the lakeshore west of the northern half of the esker dividing Seeber Lake, a well-exposed matrix-supported conglomerate contains pebble and rare cobble (64 to 256 mm) size clasts. These clasts, which are rounded to angular and are roughly equant in shape, are composed predominantly of white quartz, thinly laminated chert, white granular-looking arenite, and rare dark green to black mafic metavolcanic clasts. The dark grey matrix contains abundant granule- and sand-size clasts of similar composition. A thin section of this matrix contains sand-size clasts of polycrystalline aggregates or single crystals of quartz, clasts consisting of plagioclase and epidote aggregates, quartz plagioclase - sericite - mudstone chips, and unidentified feldspathic lithic clasts. These clasts total approximately 40 percent of the thin section and are in a fine-grained matrix composed of 30 percent quartz and plagioclase, 30 percent sericite, and minor biotite, chlorite, and opaque minerals.

Poorly exposed matrix- to clast-supported, strongly foliated conglomerate on the west shore of Seeber Lake contains dark grey to black mudstone clasts and less abundant white, pebble-size, rounded quartz clasts in a dark grey wacke to mudstone matrix. Thin sections contain sand-size clasts of single crystals of quartz and, more commonly, lithic clasts composed of variable proportions of very fine grained plagioclase, quartz, biotite, sphene and leucoxene, epidote, tourmaline, and opaque minerals. The clasts are enclosed in a matrix of very fine grained quartz, plagioclase, sericite, biotite, chlorite, epidote, sphene, tourmaline, and opaque minerals.

Chemical Metasediments

Chert, Magnetite Ironstone, Iron Silicate Rock Chert beds, occurring in thin, fairly continuous layers less than 20 cm thick, are commonly associated with massive or pillowed mafic flows throughout the map area. Units of 3 m thick, thinly laminated to very thinly bedded (less than 0.3 to 3 cm) magnetiferous chert with small proportions of iron silicate - rich rock are associated with clastic rocks at the west end of Lingman Lake, on Lawson Lake, and across the centre of Seeber Lake. Two similar 30 m thick units are associated with mafic and felsic metavolcanics and clastic metasediments along the south shore of Tequila Lake. Where the proportion of magnetite is greater than one third by volume, individual layers and, rarely, whole units are classed as magnetite ironstone.

Units composed predominantly of thickly laminated to thinly bedded (0.3 to 10 cm) iron silicate minerals occur with minor chert and/or magnetite in a few outcrops. At the west shore of Seeber Lake, such sequences exceed 3 m in thickness. South of Tequila Lake, the units are probably greater than 10 m thick. These chemical metasediments are commonly interbedded with small amounts of clastic rocks and contain high proportions of coarse almandine garnet.

Chert units are white or, where they contain magnetite, grey or black on fresh and weathered surfaces. Iron silicate rocks are dark green to black on fresh and weathered surfaces and are easily confused with dark green mafic metavolcanics. They may be distinguished, however, on fresh surfaces by the characteristically acicular habit and slight blue-green tint of the amphiboles. Thin sections of magnetite-rich chert and iron silicate rock contain mostly grunerite intermixed with a blue-green soda amphibole, quartz, magnetite, and garnet with minor proportions of sphene and leucoxene, biotite, and chlorite. Samples from the south shore of the Seeber River at the west end of Lingman Lake contain appreciable graphite.

Intermediate to Felsic Intrusive Rocks

Granodiorite, Tonalite, Granite The metavolcanics and metasediments are surrounded by and, close to the greenstone-granitic rock contact, intruded by predominantly equigranular granodiorite, tonalite, and granite (nomenclature of Strecheisen 1975). These granitic rocks are part of a vast area mapped by Bennett and Riley (1969) as granite, granodiorite, quartz monzonite, trondhjemite (probably

tonalite), quartz diorite, and migmatite. In the present map area, by far the most abundant granitic rock-type is moderately to strongly foliated, medium- to fine-grained granodiorite which forms several irregular stocks and plutons which have been intruded by numerous pegmatitic to aplitic, rarely feldspar-phyric, granodiorite, or granite dikes. North of the shaft on the property of Twin Gold Mines Limited, the granodiorite contains a non-penetrative fracture set which trends approximately N30E. Throughout the belt, the granodiorite, is white to light grey but, more commonly, pink on fresh and weathered surfaces. Stained hand specimens contain plagioclase with 25 to 35 percent quartz, 12 to 27 percent potassium feldspar, and 1 to 15 percent biotite and/or hornblende. Opaque minerals are very minor accessory components. Rocks classified as granite are similar in appearance and mineralogy to the granodiorite but contain a higher proportion of potassium feldspar.

Tonalite, found mainly south of Tequila Lake and Seeber Lake, forms weakly to moderately foliated, irregular stocks and plutons which have been intruded by a smaller number of granodiorite or granite dikes. The tonalite is light to medium grey and is commonly richer in mafic minerals (5 to 20 percent) and poorer in potassium feldspar than the granodiorite. Thin sections contain plagioclase, quartz, biotite, hornblende, potassium feldspar, and very minor opaque minerals.

Dikes and sills of granodiorite, tonalite, and granite, commonly less than 1 m thick, intrude the supracrustal rocks close to the greenstone-granitic rock contact. Equigranular aplitic to pegmatitic phases are the most common, however, feldspar and quartz-feldspar phyric dikes do occur.

A pluton of tonalite which contains xenoliths of darker granitic rock (see below) intrudes the supracrustal rocks in the western half of Seeber Lake. This rock-type, found mainly in isolated outcrops on islands and as a narrow dike cutting the mafic metavolcanics on the west shore, forms a pluton of undetermined extent or shape. Thin sections of this rock contain 60 percent medium-grained material consisting of 65 percent euhedral plagioclase, 5 percent quartz, and 30 percent biotite, and 40 percent fine-grained material consisting of 35 percent plagioclase and 65 percent quartz.

At many locations, but most notably in the vicinity of Pullen Lake, Tequila Lake, and the southern part of Seeber Lake, granodioritic and, more rarely, tonalitic rocks contain up to 5 percent well-rounded xenoliths. These xenoliths appear to be composed predominantly of medium to dark grey weathering, medium-grained, weakly to moderately foliated, commonly feldspar-phyric granitic rocks and, rarer, medium to dark green mafic metavolcanics. In 1 outcrop on the north shore of Tequila Lake, in what is probably a dike, sharply angular to rounded, equant, medium to dark grey weathering granitic xenoliths up to 1 m across and rounded, apparently bedded mafic metavolcanic xenoliths up to 1 by 20 cm are surrounded by medium grey weathering, possibly granodioritic rock which comprises less than 5 percent of the outcrop. South of Tequila Lake, xenoliths in tonalitic to granodioritic rocks include a rounded equant block of tonalite measuring 4 m across, and 100 m from the greenstone-granitic rock contact, an angular, 5 by 7 m block composed of magnetite-rich chert and iron silicate rock.

Feldspar Porphyry and Quartz-Feldspar Porphyry Fine-grained, moderately foliated, near-vertical feldspar and quartz-feldspar porphyry dikes and sills intrude the supracrustal rocks throughout the map area. One such dike, trending N55E, crosscuts mafic metavolcanics and granodiorite to granite sills 400 m west of the shaft on the Twin Gold Mines Limited (6) property. Northeast of this feldspar porphyry, a macroscopically similar dike, also trending N55E, crosscuts the granodiorite north of the greenstone-granitic rock contact. These dikes, which are about 1 to 2 m thick, are foliated parallel to their own contacts, at least within 20 cm of the contact, and are typical of the dikes in the map area. Much thicker dikes and, more commonly, sills of similar composition occur along the south shore of Durrel Lake and south of Tequila Lake. An irregularly shaped pluton, much richer than the average in quartz phenocrysts, occurs south of Seeber Lake.

The feldspar- and quartz-feldspar-phyric intrusive rocks are medium to dark grey on fresh and weathered surfaces. Plagioclase phenocrysts up to 3 mm in size or quartz phenocrysts up to 1 mm in size may each constitute up to 20 percent of rock volume. Petrographic examination shows these rocks to contain plagioclase and quartz phenocrysts in a fine-grained matrix composed of plagioclase and variable proportions of quartz, biotite, amphibole, and opaque minerals.

Light grey feldspar porphyries are macroscopically similar in appearance to some feldspar-phyric intermediate to felsic pyroclastic rocks at the south end of P.S. Lake.

Quartz Porphyry and Feldspar-Quartz Porphyry Quartz-phyric or, more rarely, feldspar-quartz-phyric dikes and sills intrude the supracrustal rocks at Lingman Lake, north of Lingman and Seeber Lakes, and close to the greenstone-granitic rock contact in the southeastern part of Seeber Lake. These porphyries commonly occur as isolated outcrops making it difficult to estimate thickness etc., however, a probable sill on an island close to the north shore of Lingman Lake is at least 10 m thick. In the southeastern part of Seeber Lake, quartz-rich porphyry appears to be associated with feldspar and quartz-feldspar porphyry but on the Twin Gold Mines Limited property, quartz porphyry appears to be associated with feldspar-phyric granodiorite and granite related to the granitic pluton to the north.

Quartz and feldspar-quartz porphyries are white, or light brown where stained by iron oxide, on both fresh and weathered surfaces. Quartz phenocrysts up to 2 mm in size and plagioclase phenocrysts rarely exceeding 1 mm in size are found in a matrix of very fine grained plagioclase and quartz.

Hand specimens of quartz porphyry are identical to samples of massive, quartz-phyric, felsic tuff, and/or flows south of Tequila Lake.

Mafic to Intermediate Intrusive Rocks

Quartz Gabbro and Porphyritic Quartz Gabbro Quartz gabbro dikes, rarely exceeding 1 m in thickness, cut the supracrustal and surrounding granitic rocks in the vicinity of Tequila Lake and, to a lesser extent, near Pullen Lake. At Pullen Lake, a dike of quartz gabbro cuts the large, granodiorite pluton and is, in turn, crosscut by a younger, relatively coarse-grained granodiorite dike. Quartz gabbro dikes intruding the metavolcanics south of Tequila Lake are commonly crosscut by granodiorite and granite dikes and sills.

Weathered surfaces of quartz gabbro are dark green and black and fresh granular-looking surfaces are dark green and brown-green. These dikes are commonly plagioclase- and/or amphibole-phyric. Feldspar averages less than 2 mm in size but range up to 3 m. Amphibole commonly forms acicular crystals up to 4 mm long. Thin sections contain up to 15 percent amphibole and less than 1 percent plagioclase phenocrysts in a fine-grained or, rarely, medium-grained matrix composed of 25 to 45 percent amphibole, 45 to 60 percent plagioclase, up to 10 percent quartz, up to 3 percent sphene, and minor epidote and opaque minerals. Hornblende or, in places, actinolite are intimately intermixed with biotite which forms up to 10 percent of rock volume. The twinned, moderately saussuritized plagioclase has an anorthite content greater than 50 percent.

One quartz gabbro dike south of Tequila Lake is zoned. A 5 cm wide zone along the contact with the country rock contains 50 percent hornblende, including phenocrysts up to 3 mm in size, and almost no biotite. The central part of the 1 m wide dike contains 35 percent hornblende and 10 percent biotite. Other unzoned dikes contain biotite right to the contact. In all of the dikes, biotite foliation which parallels their strike is best developed close to the contacts. In the central parts of dikes, the orientation of biotite crystals is more random.

Ultramafic Intrusive Rocks

Serpentinized Pyroxenite Unfoliated serpentinized pyroxenite occurs in 4 small outcrops at an unnamed lake 1.5 km west of Tequila Lake. Although these rocks have been shown as an intrusive unit, no evidence either in the field or in the laboratory excludes an extrusive origin. The pyroxenite is dark green to black or medium to dark orange-brown on weathered surfaces and is dark green or mottled light and dark green on fresh surfaces. Abundant, rarely polygonal, fractures are commonly filled with glossy-looking, light green or bright green and red chrysotile serpentine. Chrysotile fibres, aligned perpendicular to fracture walls, are not commonly visible in hand specimens. As observed in thin section, 1 sample contains 63 percent serpentine, 25 percent tremolite, 10 percent chlorite, and 2 percent opaque minerals. A second sample contains 25 percent serpentine, 30 percent talc, 10 percent tremolite, 10 percent chlorite, 20 percent olivine, and 5 percent opaque minerals. The serpentine is predominantly antigorite with minor chrysotile being mostly in fractures. Very fine grained opaque minerals, probably magnetite, are generally bordered or enclosed by serpentine. Bright red, probably secondary limonite or hematite stain some serpentine veins. Olivine crystals are, in part, relatively unaltered and it seems likely that the proportion is approximately the same as the original olivine content. Prior to alteration, the 2 samples may thus have been composed of approximately 100 percent and 80 percent pyroxene, respectively.

MIDDLE OR LATE PRECAMBRIAN (PROTEROZOIC)

Mafic Intrusive Rocks

Diabase, olivine diabase, and porphyritic diabase dikes and sills occur in the area. A northeastward trending, unfoliated, 50 m wide post-Archean diabase dike is easily traced across most of the map area in outcrop and by its aeromagnetic expression. This dike has been offset by as much as 1 km along right-handed, near vertical, strike-slip faults (see section "Structural Geology"). North of Lingman Lake, the diabase apparently forms a number of parallel, *en echelon* segments so that, although the overall trend of unfaulted segments is approximately N10E, the trends of observed contacts average N23E (Figure 2). Apparent left-hand "offsets" of the diabase, resulting from the *en echelon* pattern of intrusion, range from less than 1 m to at least 20 m. As reported by J.A. Reid (1946) for Lingman Lake Gold Mines, diamond drilling has indicated that the dike dips 76 degrees to the east in the vicinity of the Twin Gold Mines Limited shaft. Company maps of Lingman Lake Gold Mines, originally included in a report by R. Thomson (1947), show left-handed "offsets" similar to those described here (see Figure 3). The continuity of the dike is not well defined across the western end of Durrel Lake where aeromagnetic maps (see Table 2) suggest the presence of more than 1 dike.

A few, much narrower dikes were noted in mapping but none could be traced along strike for more than a few tens of metres.

Fine-grained, very narrow diabase dikes and fine-grained chill margins on thicker dikes show a diabasic texture and are black on fresh surfaces and black or medium to dark orange-brown on weathered surfaces. Medium-grained thicker dikes are mottled light and dark green on fresh surfaces and mottled medium and dark green to black on weathered surfaces. Both fine- and medium-grained dikes are commonly porphyritic with plagioclase phenocrysts up to 5 mm in size. Thin sections contain 60 percent plagioclase, 30 to 40 percent pryoxene, up to 5 percent olivine, and up to 20 percent opaque minerals. Relatively unaltered plagioclase crystals have anorthite contents greater than 50 percent.

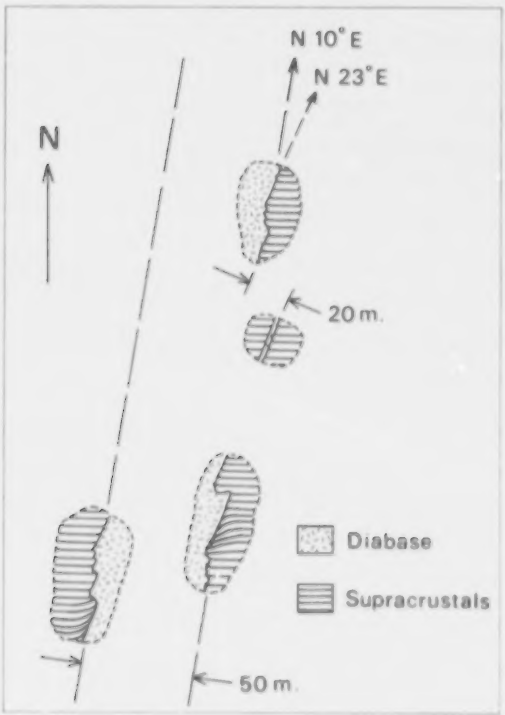

Figure 2. *Cartoon of diabase dike contacts on the property of Twin Lake Gold Mines Limited.*

PHANEROZOIC

CENOZOIC

Quaternary

Pleistocene and Recent

Till, Sand, Gravel, Silt, Clay In the present study, Pleistocene and Recent unconsolidated sediments were given only cursory examination. Bedrock outcrops, commonly of low relief are surrounded by poorly sorted tills composed of sand- to boulder-size clasts and somewhat better sorted, intermixed deposits of sand, gravel, silt, and clay. Only rarely are there relatively broad, flat areas of gravel and finer sediments. Most flat areas in the map area are low and swampy and are probably thickly covered by peat. The north shores of lakes are generally mantled by deposits of pebbles, cobbles, and, rarely, boulders, whereas south shores are less extensively covered by unconsolidated sediments. Intersections of unconsolidated surface material recorded in diamond-drill hole logs (see Table 2) are generally short, thus Pleistocene and Recent cover in the map area is probably quite thin.

An exception to the predominantly thin nature of overlying sediments occurs in the western half of the map area where a relatively high, sinuous esker crosses Seeber Lake. Other glacial features include fairly abundant *roches moutonées*, glacial striae, and a few elongate, northward trending mounds of sand and gravel which may be drumlins.

A surficial geology map by V.K. Prest (1963) covers an area beginning 100 km south of Lingman Lake from Sandy Lake to Red Lake and another by S.C. Zoltai

(1965) covers the area south of Red Lake beginning 325 km south of Lingman Lake. Zoltai shows in the area of Red Lake predominantly ground moraine of silty to sandy till and lesser volumes of lacustrine silt, sand, and varied silt and clay. The map by Prest shows only the distributions of bedrock and drift, however, his accompanying report contains a detailed examination of sediment types and the history of deglaciation which are probably partially applicable to the Lingman Lake area. The oldest glaciation suggested by Prest, inferred from rarely preserved older striae, involved a northwestward moving ice sheet during what may have been the Wisconsinan period.

Glacial striae trend N10E throughout most of the Lingman Lake area. J. Satterly (1938) reported striae trends at Seeber Lake from 52°E to 55°E. Striae and *roches moutonées* found during the present study indicate that ice movement was to the south. A southward moving ice sheet would be expected to remove unconsolidated material from the northern face of outcrops and to deposit it on the southern side, a pattern which corresponds to the observed sediment-free northward facing and sediment-covered southward facing shores.

Pleistocene sediments deposited in the Lingman Lake area comprise ground moraine of poorly sorted till, an esker of glaciofluvial sand and gravel and, possibly, a few drumlins and minor deposits of glaciolacustrine sand, silt, and clay. Other probably Recent sediments comprise minor fluvial, lacustrine, and swamp deposits of gravel, sand, silt, and clay.

Alteration

Over broad areas, most notably along most of the east shore of P.S. Lake, across the southern half of Seeber Lake, and on the property of Twin Gold Mines Limited, medium-grained, massive mafic flows have been weakly to very strongly altered. The degree of alteration is approximately indicated by the colour of these flows. Strongly altered flows are almost completely white on both weathered and fresh surfaces and less altered flows are mottled, light to medium shades of green. White or lighter shades of green are commonly associated with relatively narrow, strongly foliated, probably fault zones within broad, medium green, altered zones.

In altered flows, amphiboles have been altered to uralite (a fine-grained, fibrous amphibole) and variable proportions of chlorite, carbonate, sericite, opaque minerals, and serpentine, mainly chrysotile. Plagioclase crystals have been partly or almost completely saussuritized and enclose epidote, zoisite, sericite, and carbonate. Small quartz grains are commonly included in altered amphibole and plagioclase. Opaque minerals are completely altered to, or are rimmed by, coarse-grained or very fine grained sphene and leucoxene. One sample was found to be relatively unaltered except close to brittle fractures filled with a mixture of quartz and sericite.

In many narrow highly foliated zones, generally less than 1 m across, alteration is dominated by silicification and the introduction of sulphide minerals, mainly pyrite. Such zones are found within most metavolcanics, metasediments, and intermediate to felsic rock-types. Similar zones crosscut the large diabase dike. Altered rocks in these zones look more siliceous and are commonly brighter in colour than unaltered equivalents. Sericite and up to 20 percent sulphide minerals are commonly in zones a few centimetres wide. Weathered surfaces tend to be stained dark brown and black by iron oxides. Where they are washed by wave action along lakeshores, altered mafic metavolcanics are characteristically light to medium yellow-green and brown-green.

Minerals in the silicified zones and identified in hand specimen include carbonate, possibly in part ankeritic, tremolite to actinolite, chlorite, fuchsite, sericite, and quartz. Carbonate, generally associated with acicular, radiating aggregates of actinolite or tremolite, forms more than half of some altered zones. Weathered surfaces of carbonate are highly friable, unfoliated, and are white to light brown. Highly discontinuous, boudinaged amphibole-rich layers stand out in relief on recessive weathering carbonate. Fuchsite occurs north of Seeber and Lingman Lakes and in great abundance south of Seeber River between P.S. Lake and Seeber Lake.

Microscopic examination indicates that, in varying degrees, amphibole group minerals have been uralitized; plagioclase has been saussuritized; opaque minerals have been rimmed by or altered to sphene and leucoxene and quartz, carbonate, sericite, chlorite, epidote, and opaque minerals have been added during alteration. The minerals formed are commonly coarser than pre-existing crystals in some rock-types.

Structural Geology

FOLIATION

Supracrustal rocks in the Lingman Lake greenstone belt are weakly to very strongly foliated whereas surrounding intrusive rocks are moderately to strongly foliated or rarely weakly foliated. Degrees of foliation are, however, somewhat subjective and refer only to the apparent extent to which foliation, marked by the parallel arrangement of inequant minerals or clasts or by closely spaced, differentially weathered parallel fractures, is obvious on weathered outcrop surfaces. A parallel arrangement of minerals is, in fact, in virtually every rock-type except the post-Archean diabase and the rock varieties which contain little or no platy or acicular minerals. Such foliations are parallel or subparallel to bedding throughout the map area. Foliations marked by fractures also tend to parallel bedding except where the fractures are the result of faulting or secondary cleavages (see Folds). Pillows and varioles are commonly flattened parallel to foliation and elongated within the plane of foliation so that their long axes pitch 90 degrees, parallel to mineral lineations on foliation surfaces.

FOLDS

Folding is present on all scales. On the basis of numerous stratigraphic top determinations, some of which are shown on the map, the traces of axial planes of 2 synclines and an anticline have been delineated. The axial trace of the northern syncline which passes through Seeber Lake ends on or near the property of Lingside Copper Mining Company Limited (3). The nature and exact location of the termination could not be determined in the present study. The axial trace of the southern syncline interpreted here as passing through Durrel Lake may extend farther eastward across Tequila Lake.

Minor, "S" and "Z" shaped folds are common and are most easily seen in well-bedded, metasediments and clastic metavolcanics. As shown schematically by the curvature of lithological contacts, minor folding is especially well developed southwest of Durrel and Seeber Lakes within 3 km of the contact between the supracrustal and granitic rocks. Symmetrical folds with horizontal or near-horizontal axes occur the east end of Lawson Lake, south of Tequila Lake, and west of Seeber Lake. East of Lawson Lake, this folding gives rise to both north and south top determinations.

Mineral foliations parallel bedding through minor folds. Later foliations defined by 2 sets of vertical cleavage developed axial planar to the minor folds. Cleavages are best developed in metasediments along Lingman Lake and across Seeber Lake, in which "S"-folds and the associated southeastward trending cleavage predominate. Cleavages change trend or refract between rock layers of different grain sizes. In 1 outcrop at the east end of Lingman Lake, cleavages trend S20E in sandy layers and S70E in muddy layers. At Seeber Lake, a fold with a wavelength and amplitude in the order of a few tens of metres is cut by southeastward trending, near vertical cleavage planes on both limbs.

A pair of granitic dikes close to the shaft on the property of Twin Gold Mines Limited has intruded the metavolcanics along what were probably 2 mutually-perpendicular fractures related to the cleavages elsewhere in the map area. During continued deformation and counterclockwise rotation, the southeastward trending dike was elongated, thinned, and boudinaged whereas the northeastward trending dike was shortened, thickened, and folded. Most of the granitic dikes in this area have been rotated so that they are now almost parallel to volcanic layering.

FAULTS

Abundant vertical or near-vertical faults and fault zones, generally less than 1 m across, are present in all lithologies in the map area. Fault trends average S60E to S80E. A few relatively minor faults parallel the southeastward trending cleavage and 2 very minor, low angle thrust faults crosscut the metavolcanics and bordering granitic rocks. Where observed, slickensides, which are invariably horizontal or gently eastward plunging on the strike-slip and thrust faults, indicate that all of the vertical faults are right-handed. Mineral alignments resulting from fault slip are

found where faults parallel local foliation as lineations pitching at very small angles on foliation surfaces.

Faults and fault zones typically marked by wave-like cataclastic textures on microscopic to macroscopic scales are moderately to strongly altered. Slickensides are common on the surfaces of sulphide minerals, mainly pyrite, and other minerals which developed during alteration. Offsets on observed and interpreted faults range from a few millimetres to as much as 1 km.

Narrow, relatively discrete faults marked by the presence of near-horizontal slickensides on highly chloritic surfaces occur in diabase dikes at the north end of P.S. Lake. Broader fault zones, delineated mainly by the presence of slickensides on sericitic surfaces, cut the granitic rocks at Pullen Lake, south of Durrel Lake, and at the east end of the small lake east of Tequila Lake, outside of the map area.

On the property of Twin Gold Mines Limited, faults are approximately layer parallel. Where the metavolcanics are folded into broad open folds, faulting and mineralization follow the bedding but where the rocks are folded into tight closed folds, faults and mineralization crosscut bedding. Elsewhere in the map area, faults more commonly crosscut local stratigraphy.

Economic Geology

SUMMARY OF MINERAL DEPOSIT TYPES

Mineralized zones are abundant throughout the Lingman Lake area, however most involve only pyrite with pyrrhotite and very minor chalcopyrite. Such occurrences are so numerous and widely distributed that, given their low economic potential, they have not been included on the map. The approximate location of all other mineralization is shown on the map.

Most, if not all, of the mineralization is interpreted by the author to be related to alteration along faults and within fault zones. The only likely exceptions are molybdenite, gold, and silver showings. Fault zones vary in width from a single fracture to as much as a kilometre or more. Individual veins, however, rarely exceed a fraction of a millimeter in thickness and highly mineralized zones rarely exceed 1 m across.

Gold and silver have, so far, been found north of Lingman Lake and north of Wigwam Lake within 1 km of the supracrustal-granitic rock contact along the northern edge of the greenstone belt. Molybdenite was found in metavolcanics on fracture surfaces and in granitic dikes along both the northern and southern edges of the "greenstone" belt. All of the occurrences lie within 1.5 km of the greenstone-granitic rock contact. In the present study, an analyzed sample of a molybdenite-bearing, 30 cm wide granitic dike from south of Durrel lake was found to contain 3260 ppm or 0.33 percent molybdenum.

Pentlandite, galena, and sphalerite have been reported in the vicinity of Wigwam Lake and galena has been reported from underground on the Twin Gold Mines Limited property. Again, these occurrences lie relatively close to the greenstone-granitic rock contact. Pyrite, pyrrhotite, chalcopyrite, and arsenopyrite are widely distributed throughout the belt. An analyzed sample of arsenopyrite-bearing conglomerate collected by the field party on the west shore of Seeber Lake contained 79 ppm copper, 72 ppm nickel, and trace silver and gold.

In September 1981, the only known deposit of economic significance in the Lingman Lake area was the gold occurrence of Twin Gold Mines Limited. Underground exploration and surface and underground diamond drilling have indicated the presence of 444,000 tons of ore averaging 0.41 ounces of gold per ton and 130,000 tons of ore averaging 0.21 ounces of gold per ton (Northern Miner Press 1974). The most favourable host rocks for gold mineralization, commonly accompanied by pyrite, some arsenopyrite, and rarely pyrrhotite, galena, and chalcopyrite, are silicified mafic metavolcanics, especially in close proximity to the ends of bodies of mylonitized quartz porphyry.

DESCRIPTION OF PROPERTIES AND OCCURRENCES

Current and defunct properties for which geological or related mineral exploration information is available in the assessment records on file at the Assessment Files Research Office, Ontario Geological Survey, Toronto, or at the Resident Geologist's Office, Ministry of Natural Resources, Red Lake, or in mineral deposit records on file at the Geoscience Data Centre, Ontario Geological Survey, Toronto, are listed below. Property location numbers used on the accompanying map correspond with those beside each company name. The numbers on the map indicate the approximate centres of claim groups or, for larger blocks, the approximate area covered by exploration activity. A date in square brackets indicates the date of last known exploration. Locations of diamond-drill holes and surveyed claims are approximate. Geology is not tied to surveyed lines.

Exploration activity is summarized in Table 2.

INTERNATIONAL MINERALS AND CHEMICAL CORPORATION (CANADA) LIMITED [1967] (1)

In 1967, International Minerals and Chemical Corporation (Canada) Limited held a large number of claims in the vicinities of Durrel and Seeber Lakes. Exploration work was carried out primarily on a block of 142 claims near Durrel Lake and 43 claims in 2 groups near Seeber Lake. The claims near Seeber Lake were numbered

TABLE 2. EXPLORATION ACTIVITY IN THE LINGMAN LAKE AREA.

Property	Location	Airborne Electromagnetic	Ground Electromagnetic	Airborne Magnetic	Ground Magnetic	Induced Polarization	Geological Mapping	Rock Geochemistry	Soil Geochemistry	Underground Development	Toronto File Numbers	Diamond Drilling	Toronto File Numbers (For Diamond Drill Information)
Amoco Canada Petroleum Co. Ltd.*	North of Lingman Lake	M	M R		M R		M R	M R	M R		2-3684		
International Minerals and Chemical Corp. (Canada) Ltd. (1)	West End of Durrel Lake	M R		M R			M R				63-2037 63-2212 63A-537		
	Area of Seeber Lake	M R	R	M R		M R	M R				63-2037 63A-519	L	Lingman 10 Seeber 10 to 14 Vanderbrink 10 to 13

*Not in text or on map.
X = activity reported
M = map on file
R = written report on file
L = drill logs on file

All files are in the Assessment Files Research Office, Ontario Geological Survey, Toronto except M.D.53/15 which is a Mineral Deposit Record on file at Geoscience Data Centre, Ontario Geological Survey, Toronto. Assessment files, filed in a different manner, are also available at the Resident Geologist's Office, Ministry of Northern Development and Mines, Red Lake, Ontario.

TABLE 2. cont'd.

Property	Location	Airborne Electromagnetic	Ground Electromagnetic	Airborne Magnetic	Ground Magnetic	Induced Polarization	Geological Mapping	Rock Geochemistry	Soil Geochemistry	Underground Development	Toronto File Numbers	Diamond Drilling	Toronto File Numbers (For Diamond Drill Information)
Kennco Explorations (Canada) Ltd. (2)	All but Tequila Lake	X		M			X				63-2899		
Lingside Copper Mining Co. Ltd. (Lingside Gold Mines (3)	Northwest of Lingman Lake						M				63-3332	X	M.D.53 F/15
Roman Corp. Ltd. (Winora Gold Mines) (4)	North of Lingman Lake				X						M.D.53 F/15	X	M.D. 53 F/15
Silveroc Mines Ltd. (Effie Johnson, Internationa Minerals and Chemical option (5)	North of Seeber Lake				X		M R				2-663	L	Vanderbrink 10, 11, 14 to 16
Twin Gold Mines Ltd. (Lakelyn Mines, Lingman Lake Gold Mines) (6)	North of Lingman Lake						M R			R	63-3010 63-3332 M.D.53 F/15	X	63-3010 63-3332 M.D.53 F/15

KRL 53218, KRL 56005, KRL 56008, KRL 56018, KRL 56020, KRL 56023, KRL 56118, KRL 56132, KRL 56188, KRL 56189, KRL 193, KRL 194, KRL 56198 to KRL 56205 inclusive, KRL 56838 to KRL 56843 inclusive, KRL 56954, KRL 57127 to KRL 57129 inclusive, KRL 57131 to KRL 57134 inclusive, KRL 57140, KRL 57141, KRL 57144, KRL 57147, KRL 57171, KRL 57172, KRL 57174, KRL 57175, and KRL 57861.

The first recorded exploration work by International Minerals and Chemical Corporation (Canada) Limited consists of logs of 3 diamond-drill holes collared in 1965 on claims then optioned from Effie Johnson and now held by Silveroc Mines Limited (5). Details from logs of these holes are given below under Silveroc Mines Limited.

In 1966, a part of the Lingman Lake greenstone belt which lies west of an imaginary line drawn from the east end of Durrel Lake to the west end of Lingman Lake, was covered for International Minerals and Chemical Corporation (Canada) Limited by airborne magnetic and electromagnetic surveys, however, only the magnetic map is currently on file (Table 2). A report written by R.W. Stemp (1966) indicates that these surveys delineated a large number of anomalies divided into 66 conducting zones. The majority of the conductors were thought to be the result of deposits of massive sulphide minerals.

The 2 groups of claims at Seeber Lake, interpreted in this report to be underlain mainly by mafic to intermediate metavolcanics, granitic rocks, and in the southeastern part of the claim group metasediments, were geologically mapped by the company in 1966. These claims were further examined in 1967 by ground electromagnetic (horizontal coil) and ground induced polarization surveys. According to a report by O.L. Younge (1967), geological mapping and limited trenching indicated the presence of a few faults and 3 distinct mineralized zones. One zone was discovered in the metasediments located on the east shore of Seeber Lake near the Seeber River and 2 were found in the metavolcanics north of Seeber Lake. Mineralization consisted of disseminated pyrite, galena, sphalerite, and chalcopyrite or disseminated arsenopyrite, pyrite, and chalcopyrite. Minor pyrrhotite was found locally. In addition to these surface showings, a large number of interesting prospects were defined by the 2 geophysical surveys.

Geological mapping was also carried out on the claims around Durrel Lake in 1967. These claims are interpreted by the author to be underlain by mafic to intermediate metavolcanics interbedded with minor amounts of tuff and metasediments and by a diabase dike which trends north-northeastward through much of the claim group. This dike is offset by right-handed strike-slip faults which crosscut all of the map area. The continuity of the dike across the west end of Durrel Lake is not well defined. Airborne magnetic maps of International Minerals and Chemical Corporation (Canada) Limited and Kennco Explorations Limited (see Table 2) suggest the presence of more than 1 dike in this area. As indicated in a second report by Younge (1968), geological mapping and trenching around Durrel Lake located several faults and 2 mineralized units. Mineralization was sparse, however, and comprised minor pyrite, pyrrhotite, and chalcopyrite. One trench exposed a small fault zone in silicified mafic to intermediate metavolanics.

Follow-up diamond drilling in 1967 totalled 1775 m, in 18 holes. Four of these holes were drilled on property now held by Silveroc Mines Limited and are described below (see Silveroc Mines Limited). Four holes were drilled between Wigwam Lake and Seeber Lake, 1 was drilled 1500 m west of the tip of the narrow western arm of Seeber Lake, 1 was drilled on the southern part of the esker dividing Seeber Lake, 2 were collared on the ice east of the narrows through the esker, 5 were collared on the ice close to the eastern shore of Seeber Lake near the Seeber River, 1 was drilled in the metasediments on the shore of Seeber Lake near the Seeber River. These holes intersected mainly minor pyrite, pyrrhotite, and chalcopyrite. Minor arsenopyrite is reported in logs of 2 holes, one 400 m north of the western arm of Seeber Lake, and the other in the metasediments on the shore of Seeber Lake near Seeber River. Galena and pentlandite were found in minor amounts in the diamond-drill hole collared 100 m east of the northeast end of Wigwam Lake.

No other activity has been reported by International Minerals and Chemical Corporation (Canada) Limited and all claims held by that company have been allowed to lapse.

KENNCO EXPLORATIONS (CANADA) LIMITED [1960] (2)

Kennco Explorations (Canada) Limited flew airborne magnetic and electromagnetic surveys over all but the Tequila Lake part of the Lingman Lake greenstone belt in 1960. As reported by Bennett and Riley (1969), the company also carried out geological mapping and prospecting, however, no claims were ever recorded and no further exploration work has been reported. Only the aeromagnetic map is currently on file.

LINGSIDE COPPER MINING COMPANY LIMITED (LINGSIDE GOLD MINES) (3)

In September of 1981, Lingside Copper Mining Company Limited held a group of 14 contiguous patented claims numbered Pa 6392 to Pa 6402 inclusive and Pa 6427 to Pa 6429 inclusive. These claims, located northwest of Lingman Lake adjacent to the Twin Gold Mines property, have been interpreted in this report to be underlain mainly by mafic to intermediate metavolcanics comprising fine- and medium-grained massive flows, pillowed flows, and minor tuffs or metasediments, and minor interbedded metasediments including arenite and wacke. Chemical metasediments consisting of chert, magnetite ironstone, and iron silicate rocks occur at the northern edge of the claim group and close to the extreme southeast corner. Stratigraphic tops are to the south along the northern edge of the group and to the north along the southern edge. The syncline which is centred on Seeber Lake to the west of the claim group probably terminates within this property but the exact nature or location of the termination was not determined in this study. Altered metavolcanics, which could be on strike with the shaft sunk on the Twin Gold Mines Limited property, occur in the northern part of the claim group, however, no significant mineralization appears to be present.

According to a report on file in Mineral Deposit records (see Table 2), Steeljoy Mining Corporation Limited financed diamond drilling by Lingside Gold Mines Limited but no results were ever published. A geological map drawn in 1939 and copied by R. Thomson for Lingman Lake Gold Mines Limited in 1945 (*see* Table 2) shows 1 occurrence of quartz-carbonate mineralization and 2 outcrops of iron-rich rocks within the claim group. None of these were located by the author. No other work has been reported from this property.

As indicated by the Mineral Deposit report, Lingside Gold Mines Limited changed its name in 1951 to Lingside Copper Mining Company Limited and in 1980 the company reached an agreement with Future Oil and Gas Limited in which Future Oil and Gas Limited is required to pay all past and current property taxes on the patented ground in return for a 50 percent interest in the mineral rights. As of September 1981, these claims were in good standing.

ROMAN CORPORATION LIMITED (ROCKWIN MINES, WINORA GOLD MINES) (4)

In September 1981, Roman Corporation Limited held a group of 17 contiguous, patented claims numbered Pa 6382 to Pa 6390 inclusive, Pa 6435 to Pa 6440 inclusive, Pa 6631 and Pa 6632. The claims are interpreted here to be underlain by dominantly mafic metavolcanics comprising fine- and medium-grained, massive flows, feldspar porphyry flows, and minor tuff or metasediments. Metasediments in minor proportions interbedded with the metavolcanics consist of thin beds of chert, arenite, and wacke. Near the southern edge of the claim group is an intrusion of quartz porphyry. This part of the claim group may be underlain by metasediments similar to those found at the southern edge of the Twin Gold Mines Limited property which is adjacent to the Roman Corporation Limited group.

Stratigraphic tops, based on crossbedded and graded metasediments close to the northern edge of the claim group, are to the north. Molybdenite occurs on slip surfaces within faulted metavolcanics at 1 locality, however, no other significant mineralization was observed.

Notes from a Mineral Deposits file (*see* Table 2) indicate that in 1966, the Roman Corporation Limited amalgamated with Rockwin Mines Limited which in 1945 was known as Winora Gold Mines Limited. Winora Gold Mines Limited is reported to have carried out trenching, geophysical surveys, and diamond drilling between 1945 and 1948. Gold values from grab samples taken along strike from the Twin Gold Mines Limited property in 1945 ranged up to 0.1 ounces of gold per ton. No further exploration work has been reported and, as of September 1981, the 17 patented claims were in good standing.

SILVEROC MINES LIMITED (EFFIE JOHNSON, INTERNATIONAL MINERALS AND CHEMICAL OPTION) (5)

In September 1981, Silveroc Mines Limited held leases on 15 claims in 3 groups near Wigwam Lake northwest of Seeber Lake. Seven contiguous claims located at the southwest end of Wigwam Lake are numbered KRL 53197, KRL 224132 to KRL 224134 inclusive and KRL 223241 to 223243; 6 contiguous claims on the north-central shore are numbered KRL 53208 to KRL 53210 inclusive, KRL 53212, KRL 53213 and KRL 53216 and 2 contiguous claims at the northeast end are numbered KRL 223246 and KRL 223247. In 1971 these and 29 other claims numbered KRL 223244, KRL 223245, KRL 223248 to KRL 223250 inclusive, KRL 260126 to KRL 260130 inclusive, KRL 53196, KRL 53198 to KRL 53207 inclusive, KRL 53211, KRL 53215, KRL 53217, KRL 53218 and KRL 224128 to KRL 224131 inclusive were held by Effie Johnson. All of these claims were under option to International Minerals and Chemical Corporation (Canada) Limited during 1965, 1966, and 1967.

The claims leased by Silveroc Mines Limited are underlain mostly by mafic to intermediate metavolcanics comprising dominantly fine- and medium-grained massive flows and pillowed flows with minor interbedded tuff or metasediments. These rocks are commonly faulted and altered in the area of Wigwam Lake. Several silicified and mineralized zones containing mostly pyrite are present. Stratigraphic tops, locally derived from pillow shape and packing, are to the south.

A report by R.J. Hartmier *et al.* (1971) indicates that exploration work conducted on this property has included considerable trenching and blasting, a magnetic survey of the southwest claim group, and, in 1977, a geological survey of the area by Effie Johnson. Airborne magnetic and electromagnetic surveys flown in 1966 and an induced polarization survey flown in 1967 for International Minerals and Chemical Corporation (Canada) Limited (see above) covered the claims at Wigwam Lake. On file are data from the geological, airborne magnetic, and ground induced polarization surveys (see Table 2). The results of the ground magnetic and airborne electromagnetic surveys have not been reported.

According to Hartmier *et al.* (1971), geological and geophysical surveys have indicated the presence of a large number of prospects. Geological maps produced by Effie Johnson show trench locations and, in the southwest claim group, some of approximately 40 reported mineralized occurrences. Minerals occurring in trenches on claim KRL 53197 are shown on the geological map (back pocket) and include pyrite, pyrrhotite, chalcopyrite, arsenopyrite, molybdenite, silver, and gold. Other mineralization seen by this field party in trenches and on outcrops in the remainder of this group include pyrite, pyrrhotite, chalcopyrite, arsenopyrite, molybdenite, galena, pentlandite, and sphalerite. The report by Hartmier *et al.* suggests that the most important minerals on the claim groups are galena and sphalerite.

The earliest reported diamond drilling totals 131 m in 3 holes completed in 1965 by International Minerals and Chemical Corporation (Canada) Limited. The holes, drilled on what are now leased claims KRL 224133 and KRL 223241, intersected only minor pyrite, pyrrhotite, chalcopyrite, and galena. Analyses over 18 cm of core from a hole on KRL 224133 showed 0.26 percent lead, 0.44 ounces per ton of silver, and trace gold. Mineralization in 4 other holes totalling 380 m and drilled for International Minerals and Chemicals Corporation (Canada) Limited in 1967, included minor amounts of pyrite, pyrrhotite, chalcopyrite, and molybdenite. These 4 holes were drilled on what are now leased claims KRL 53197, KRL 53208, KRL 53213, and KRL 53216 (see map, back pocket).

Effie Johnson diamond drilled 11 holes totalling 475 m in 1971, 1972, and 1974. Ten of the holes were collared on the southwest and central claim groups on what are now leased claims KRL 223241, KRL 224134, KRL 224133, KRL 53209, and KRL 53210. The eleventh hole was drilled just south of leased claim KRL 223242. These 11 holes intersected minor pyrite, pyrrhotite, chalcopyrite, and galena. A single assay shows only trace lead, silver, and gold.

Between 1976 and 1979 Silveroc Mines Limited diamond drilled a total of 158 m in 3 holes. One of these was located east of leased claim KRL 53197 and 2 are located east of leased claim KRL 224133 (see map, back pocket). These 3 holes intersected minor pyrite, pyrrhotite, chalcoyrite, and galena.

No further work has been reported on the Silveroc Mines Limited property. The leases on their 15 claims (see map, back pocket) are due to expire in 1994 and 1995. All other claims in the Wigwam Lake area have been allowed to lapse.

TWIN GOLD MINES LIMITED (LAKELYN MINES, LINGMAN LAKE GOLD MINES)(6)

In September 1981, Twin Gold Mines Limited held a group of 21 contiguous, patented claims numbered Pa 6130 to Pa 6138 inclusive, Pa 6196 to Pa 6204 inclusive, Pa 6391, Pa 6633 and Pa 6634. Gold was first discovered in the area by A. Van der Brink in 1942 (M.G. Smerchanski, President and Director, Twin Gold Mines Limited, personal communication, 1981). In 1945 the company, then incorporated as Lingman Lake Mines Limited, purchased claims from E.G.H. Schultz, A. Van der Brink, L. Paget, and J. Kersopp and received 1 other claim in the group at no cost. The company name has since changed several times: in 1945 to Lingman Lake Gold Mines Limited, in 1948 to Lake Lingman Gold Mining Company Limited, in 1964 to Lakelyn Mines Limited, in 1978 to Lakelyn Mines Incorporated, and in 1979 to Twin Gold Mines Limited.

The earliest recorded work on file comprises 2 detailed geological maps by "P.B." dated 1938 and 1939. These maps show a part of a claim group which was staked in the same location as, but earlier than, the claims sold to Lingman Lake Mines Limited. They also show diamond-drill hole locations probably added by R. Thomson who copied the maps for Lingman Lake Gold Mines Limited in 1945. Reported exploration work by the company began with surface diamond drilling in 1945 and 1946. A report by M.G. Smerchanski (1946b) lists gold intersections from diamond-drill holes cutting 4 gold-bearing zones. This report indicates that at least 73 holes had been drilled up to that date and the locations of 51 of the holes are shown in an accompanying map. A report by R.A. Crouse (1973) states that, in 1945, a surface diamond drilling program totalled 11,174 m in 79 holes. There is no reference to the 6 additional holes in the files. This same report shows that a single deep diamond-drill hole of 302 m was completed in early 1973. Three more holes were collared to the west of this 1, as indicated by a brief newspaper account of work in progress on the property (Northern Miner 1973). No logs for any of the above diamond-drill holes are on file, however, some of the available results are summarized below.

In 1946 a 3 compartment shaft and 2 levels, 1 at 44 m and 1 at 84 m, were started. A third level at 122 m was added to the 126 m deep shaft in 1948. By 1949, underground development from the shaft included 1383 m of drifting, crosscutting and raising, and 2988 m of diamond drilling. No diamond-drill logs or level plans from the underground work are on file.

The claim group held by Twin Gold Mines Limited is underlain mainly by mafic metavolcanics and minor interbedded metasediments. Along the southern edge the group is underlain by metasediments whereas the northern edge is underlain by intermediate to felsic granitic rocks which intrude the metavolcanics. The mafic metavolcanics are crosscut by granodiorite, granite, and feldspar and quartz-feldspar porphyry in dikes averaging less than 1 m thick. The entire claim group is crosscut by the 50 m wide diabase dike.

The metavolcanics at the site of the shaft consist primarily of fine-grained flows including at least 1, or possibly several flows and 1 feldspar porphyry flow. To the north of the shaft is a medium-grained massive flow overlain to the north by

a fine-grained massive flow which is in contact with the granitic rocks. Clastic metasediments interbedded with the metavolcanics near the shaft are not obvious on surface, however, a few thin (less than 1 m) units of possible clastic origin are present. Also interbedded with the metavolcanics are a few very thin beds of chert which are traceable for considerable distances along strike.

To the southwest of the shaft on claim Pa 6138 is a group of outcrops of moderately to strongly altered, medium-grained, massive mafic flows. These rocks are, where strongly foliated, almost completely white on both fresh and weathered surfaces. They have been previously mapped as altered gabbro (Bennett and Riley 1969) or basic diorite (map copied by R. Thomson in 1945 for Lingman Lake Gold Mines Limited). Evidence gathered at these outcrops and elsewhere within the map area indicates that these rocks are mafic flows altered in broad zones paralleling faults

Along the southern edge of the claim group, clastic metasediments consist of thinly laminated to thinly bedded or, rarely, medium-bedded wacke, mudstone, quartz-granule conglomerate, and minor arenite. Along the northern edge of the claim group, granitic rocks comprise irregular plutons of granodiorite crosscut by minor volumes of aplitic to pegmatitic granodiorite and granite and granodioritic feldspar porphyry. Fine- to medium-grained dikes of granodiorite, granite, granodioritic feldspar porphyry, and feldspar-quartz porphyry crosscut the metavolcanics in the vicinity of the shaft. These dikes, predominantly between the north and south gold-bearing zones but also between the south and hanging-wall zones (Figure 3), appear to have been emplaced in fractures which correspond to the 2 cleavage sets in the metasediments along the south edge of the claim group. Dikes of feldspar porphyry crosscut the granitic pluton north of the shaft and the metavolcanics west of the shaft.

The large diabase dike, trending roughly N10E, cuts across the entire claim group and passes within 122 m of the shaft (Figure 3). Where eastward trending metasediments are in contact with the dike along the southern edge of the claim group, bedding is deformed such that units on the east side of the dike are bent towards the south as they approach the dike until they almost parallel the contact.

Close to the shaft, crossbedding in a siliceous arenite and pillow packing in a mafic flow indicate that stratigraphic tops are probably to the north. Other indications of northward younging in the metavolcanic and metasedimentary sequence underlying this property were observed 2 km east of the shaft along the regional strike and in the metasediments at the southern edge of the claim group.

All of the rocks in the claim group were cut by right-handed, near vertical, and, in the area of the shaft, approximately layer-parallel strike-slip faults subsequent to the cooling of the diabase dike. Associated with these fault zones are zones of alteration. Three zones of silicified, mineralized, possibly clastic mafic metavolcanics occur near the shaft and correspond to the north, south, and hanging-wall ore zones in Figure 3. Although mineralization observed on surface in these zones consists mainly of pyrite, many other minerals are found in the dumps adjacent to the shaft. These include alteration products such as quartz, carbonate, chlorite, sericite, and tremolite, and sulphide minerals including mostly pyrite with minor arsenopyrite and possibly pyrrhotite. Molybdenite was also found by the author on slip surfaces in a few samples of mafic feldspar porphyry flows taken from the dump.

Details of the Twin Gold Mines Limited property which follow are taken from reports (see Table 2) by R.A. Crouse (1973), J.A. Reid (1946; 1947), M.G. Smerchanski (1946a; 1946b; 1948), and by R. Thomson (1947) and from notes and newspaper clippings in Mineral Deposits files (see Table 2).

Diamond drilling by the company has indicated that the 3 main gold-bearing zones, the north, the south, and the west, pinch and swell along both strike and dip. Two of these zones, the north and the west, are thought to be a single zone cut by the diabase dike. The north and south zones are 76 to 122 m apart east of the dike and appear to diverge to the west of the dike where they are 183 to 213 m apart. The north zone, dipping 65 degrees to the south, has been traced by

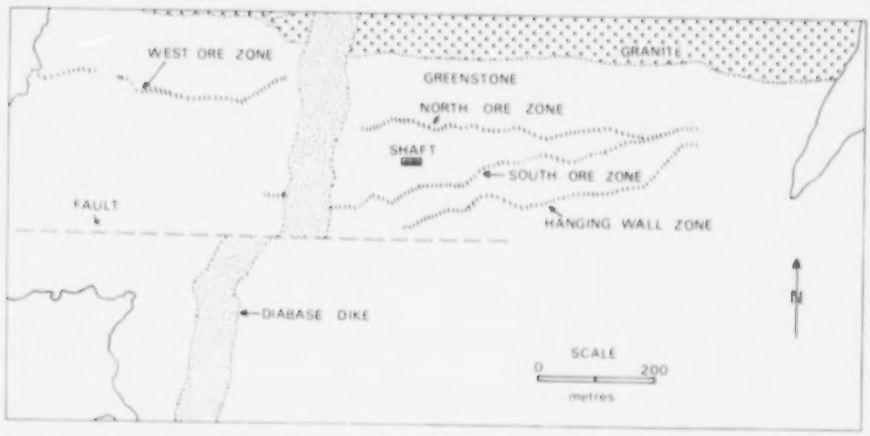

Figure 3. *Simplified geological map of the property of Twin Gold Mines Limited showing gold-bearing ore zones delineated by surface diamond drilling. Drawn after a map on file with a report by R. Thomson (1947).*

surface diamond drilling for 427 m and, at last report, is still open to the east. The south zone, dipping 80 degrees to the south and, thus, possibly intersecting the north zone at depth, has been similarly traced for 488 m. The west zone, open at both ends, has been traced by surface diamond drilling for 183 m. The widths of the north, south, and west zones are 177 cm, 183 cm, and 165 cm respectively.

Two types of porphyry occur on the property, 1 with feldspar and 1 with quartz phenocrysts. The quartz porphyry commonly faulted and altered to sericite schist is, in some places, almost entirely replaced by quartz. Mylonitized parts of a quartz porphyry which intrudes the metavolcanics between the main north and south gold-bearing zones are closely associated with good gold values. It was suggested by Reid (1946) that the porphyry could be "a phase of the hydrothermal alteration" of the metavolcanics.

The most favourable host rocks for gold mineralization were found to be silicified mafic to intermediate metavolcanics, especially proximal to the ends of bodies of quartz porphyry. Metallic minerals associated with the gold consist mainly of pyrite accompanied by some arsenopyrite, little pyrrhotite and galena, and rarely chalcopyrite. Gold values were commonly associated with the presence of arsenopyrite needles, however, good gold values were found in silicified rocks which contain only accessory pyrite. Other minerals in gold-bearing zones are quartz and carbonate (possibly, ankerite). Visible gold is very rare in this property.

The diabase dike has an average width of 67 m in the vicinity of the shaft. With an average trend of N10E and a dip of 76 degrees east, the dike is offset 76 to 91 m by a right-handed fault. Small left-handed "offsets" or bends observed by the author are not reported in the text of any report, but are evident in the map from which Figure 3 was traced. It was concluded by the company that, because of the simple existence of the west zone, the dike must be post-ore. It was further suggested that the original faulting in the area could have been pre-ore thus providing a locus for hydrothermal alteration.

The deep drilling program conducted in 1973 indicates that the south zone swings to a more southwestward trend as it approaches the diabase dike from the east. Two of these holes collared to explore the western extension of the south zone found that it continued, however, gold values were low (Northern Miner 1973).

As reported in the Northern Miner (Northern Miner 1981), underground exploration on approximately 30 percent of the known ore zones above the 122 m level has developed 148,000 tons of ore averaging 0.41 ounces of gold per ton. Diamond drilling above the 122 m level indicates the presence of a further 296,000

tons of ore averaging 0.41 ounces of gold per ton and 130,000 tons of ore averaging 0.21 ounces of gold per ton. In 1973, a deep hole, drilled at an angle of 56 degrees, intersected a zone between 283.5 and 285 m which averaged 9.5 ounces of gold per ton. A feasibility study conducted in conjunction with the drilling of the 4 holes in that year gave a combined estimate of a further 500,000 tons of ore to be found in all 3 zones below the 122 m level.

As of September 1981, the company was actively planning to put the Lingman Lake property into production (M.G. Smerchanski, President and Director, Twin Gold Mines Limited, personal communication, 1981). The feasibility study has suggested that the deposit could support a 300 ton per day operation.

No further exploration work has been reported by the company and, as of September 1981, the patented claims were in good standing.

Discussion and Synthesis

PREVIOUS MAPPING

Previous, very large scale mapping 1 inch to 2 miles by Bennett and Riley (1967a, 1967b, 1969) indicates the presence of a wide body of quartz-bearing "metagabbro" extending across Seeber Lake and P.S. Lake and in outcrops between Lawson and Lingman Lakes. In the present more detailed study, medium-grained, massive gabbroic rocks examined between Lawson and Lingman Lakes have been interpreted as relatively coarse-grained parts of thick mafic flows on the basis of grain size variations and contact relationships. Although field relationships are somewhat less obvious, similar uralitized, saussuritized, and silicified gabbroic rocks at Seeber Lake and P.S. Lake are also interpreted to be flows.

A band of carbonate in granitic rocks east of Tequila Lake outside the map area was previously mapped as marble but is interpreted in this study to be a silicified, carbonitized fault zone. Occurrences of chalcopyrite, pyrrhotite, pyrite, and arsenopyrite shown by Bennett and Riley (1967b) northeast of Seeber Lake were not located by the author and have not been included on the map.

PYROCLASTIC AND EPICLASTIC ROCKS

Although a complete discussion of the distinguishing characteristics of pyroclastic and epiclastic rocks is far beyond the scope of this report, a few points must be made. Pyroclastic and epiclastic rocks have been distinguished and classified in the legend on the basis of colour, thickness, and mica content of beds, features which appear to be closely interrelated in the Lingman Lake area. A gradational spectrum exists from thickly bedded, massive, relatively mica-free white or green pyroclastic rocks to more thinly bedded, fissile, relatively mica-rich brown or grey metasediments. This transition is best seen in the southeastern part of Seeber Lake.

Most of the metasediments in the map area are probably mixtures of detritus from mafic, intermediate to felsic, and felsic metavolcanics. Sources of clasts likely included unconsolidated pyroclastic or hyaloclastic material and debris mechanically weathered from the surfaces of mafic or felsic flows. Clasts derived from already consolidated chert, clastic metasediments, and pyroclastic rocks are also present. Abundant resistant quartz clasts in graded granule conglomerate were probably derived from quartz-phyric intrusive and extrusive volcanic rocks. The most distal metasediments, those with the highest original clay mineral content now metamorphosed to mica, occur at the extreme tips of the belt and in what will be termed here, the Seeber Lake sedimentary basin.

Sediment mixing, sorting, and chemical weathering account, in part, for the great variety of rock types observed by the author and reported by companies (see Table 2). Diamond drilling indicated a higher proportion of clastic rocks than is observed on surface, suggesting that the more friable, foliated, and cleaved outcrops of clastic rocks may have been preferentially eroded.

FOLIATION AND FOLDING

Inequant metamorphic minerals, predominantly biotite or amphibole, are commonly oriented to define planar or curviplanar penetrative foliation surfaces which approximately parallel sedimentary bedding or volcanic layering. In mudstone or wacke, the result is layer-parallel slaty cleavage. In the Lingman Lake area, mineral foliations remain roughly parallel to bedding or layering even through large- or small-scale folds. This relationship suggests that amphibole or biotite must have been aligned early in the deformation history of the supracrustal rocks. During folding, differential stresses were such that rock-units were deformed but most of the pre-existing metamorphic minerals were not recrystallized.

Two sets of non-penetrative "fracture" cleavages formed in the metasediments across Lingman and Seeber Lakes. These cleavages are oblique to bedding in unfolded rocks and crosscut both limbs of a minor fold at Seeber Lake. These relationships indicate that the development of the cleavage was probably a result of relatively large-scale stress patterns during or subsequent to folding.

FAULTING

Faults must, at least in part, postdate the intrusion and cooling of the Proterozoic diabase dikes. In a report written for Lingman Lake Gold Mines (see Table 2), Reid (1946) raises the possibility of more than 1 period of faulting along identical or parallel slip-surfaces. He concluded that movement which displaced the dike in the area of the shaft was post-ore but that earlier fault movement could have been pre-ore.

In most areas outside the Twin Gold Mines Limited property, strike-slip faults crosscut metavolcanic and metasedimentary stratigraphy and structure along trends which are remarkably consistent across the map area. Faulting which occurred before large-scale complex folding would not be expected to follow such consistent, parallel trends. Faulting could have occurred, however, in the interval between the folding of the greenstone belt and the intrusion of the diabase.

Although no evidence was observed which could either indicate or rule out more than 1 period of faulting, it is, perhaps, important that no faults or altered zones crosscut other faults. The simplest conclusion consistent with the observed data is that there was only 1 period of faulting. Whether or not this is true, faulting and associated alteration must have occurred long after volcanic activity had ceased. The continuity of faults into the granitic rocks which surround the supracrustal belt and the consistency of fault trends without respect to metavolcanic and metasedimentary stratigraphy and structure suggest that faulting was related to tectonic processes operating on a scale much larger than the size of the Lingman Lake belt.

LITHOLOGICAL RELATIONSHIPS

SUPRACRUSTAL ROCKS

From the stratigraphic and crosscutting relationships now observable in the Lingman Lake area, it appears that volcanism began with the extrusion of mafic flows and the deposition of minor volumes of related clastic rocks. Mafic volcanism was followed by at least 2, or possibly 3 intervals of felsic or intermediate to felsic volcanism in the area of Seeber Lake and P.S. Lake, and 3 to 5 intervals at Tequila Lake.

An outcrop of metasediments on a very small island in the extreme northern end of the western half of Seeber Lake is interpreted as the distal sedimentary equivalent of the pyroclastic rocks found across the syncline in the southeastern part of Seeber Lake. At Tequila Lake, the trace of the axial plane of the syncline which is interpreted to be centred on Durrel Lake may extend farther to the east, passing between the metavolcanic units south and north of Tequila Lake and, as at Seeber Lake, separating proximal from distal facies felsic and intermediate to felsic pyroclastic rocks. If this is so, there may be only 3 felsic metavolcanic sequences at Tequila Lake, 2 of them being repeated across the syncline. The intermediate to felsic metavolcanics on the north side of Tequila Lake are, however, identical with metavolcanics found at the south end of P.S. Lake, which are stratigraphically below felsic sequences at Seeber Lake. It therefore seems probable that there are 5 distinct though relatively minor sequences of felsic and intermediate to felsic metavolcanics in this region.

Alternate periods of felsic, intermediate to felsic, and mafic volcanism were followed by an extended period of mafic volcanism. Finally, in the Seeber Lake basin, there was a period of sedimentation and minor mafic volcanism. Minor volumes of clastic and chemical metasediments are interbedded with metavolcanics throughout the entire stratigraphic section.

Most of the supracrustal rocks in the Lingman Lake area have vertical or near vertical dips so that the present horizontal erosion surface reveals what were once vertical cross sections through the metavolcanics and metasediments. Vents may have been located at, below, or above the present cross section and may thus be respectively exposed, buried, or eroded away. The thickest cross section of mafic metavolcanics is located between the west end of Durrel Lake and the centre of

Seeber Lake. In the southeastern part of Seeber Lake, the low ratio of strike-length to thickness of the felsic flows suggests the flows may have formed a dome at a vent. Pyroclastic rocks associated with, and metasediments transitional to and derived from, felsic volcanism at the dome are found in a proximal to distal sequence west of the flows to the greenstone-granitic rock contact, northeast and east of the flows to the east end of Lingman Lake, and north of the flows across the Seeber Lake syncline. It is proposed by the author that a centre of felsic and probably mafic volcanism was once located close to what is now the southeastern part of Seeber Lake. No evidence was observed which would indicate other centres of volcanism, however, the considerable distance of the felsic metavolcanics at Tequila Lake from the proposed centre at Seeber Lake suggests that vents must have been located somewhere closer to Tequila Lake.

INTRUSIVE ROCKS

The youngest early Archean intrusive rocks determined by crosscutting relationships are the dikes and sills of quartz gabbro cutting the metavolcanics, metasediments, and granitic plutonic rocks in the vicinity of Tequila Lake. The quartz gabbro dikes are crosscut in turn by granodiorite to granite dikes and sills which crosscut the rocks on both sides of the greenstone-granitic rock contact throughout the map area. Feldspar and quartz-feldspar dikes and sills crosscut the metavolcanics and metasediments, the granitic dikes and sills, and, possibly, the granitic plutons. The Proterozoic diabase intrudes all other rock-types. No crosscutting relationships were observed for either the quartz or quartz-feldspar porphyries or for the pyroxenite.

Unlike mafic metavolcanics elsewhere in the belt, both the quartz gabbro dikes and the relatively thick medium-grained conformable body extending along the south shore of Tequila Lake contain biotite, quartz, and primary sphene (not leucoxene). Although the biotite, quartz, and sphene could be the products of later alteration, the biotite-free nature of chilled margins of 1 quartz gabbro dike suggests that biotite was an original component which crystallized after intrusion. In most quartz gabbro dikes, however, biotite foliations which parallel dike contacts indicate that biotite was an original component which crystallized prior to intrusion.

Feldspar and quartz-feldspar porphyry are macroscopically and microscopically similar to feldspar porphyry which is evidently related to the granitic plutons, and to intermediate to felsic pyroclastic rocks at the south end of P.S. Lake and north of Tequila Lake. Quartz or feldspar-quartz porphyries are macroscopically and microscopically similar to felsic quartz- or quartz-feldspar-phyric flows and pyroclastic rocks in the southeastern parts of Seeber Lake and south of Tequila Lake. The apparent similarities of these rock-types suggest that they may be genetically related.

A xenolith-bearing tonalite which intrudes the metavolcanics and metasediments at Seeber Lake contains 60 percent medium-grained minerals comprising 63 percent plagioclase, 5 percent quartz, and 30 percent biotite in a fine-grained matrix of 35 percent plagioclase and 65 percent quartz. The fine-grained matrix is interpreted by the author to represent the proportion of the tonalite which was a melt when it intruded.

Although the intrusive relationship between the metavolcanics and metasediments and the surrounding granitic rocks indicates that the granitic rocks must be younger, this is in conflict with the fact that dikes apparently related to volcanism, most notably those of quartz gabbro, are found crosscutting the granitic plutons. It is suggested here that the granitic rocks are the partly remobilized and deformed basement on which the supracrustal rocks were deposited.

PETROGRAPHY AND METAMORPHISM

In the Lingman Lake area, mafic flows are characterized by the presence of plagioclase and an amphibole. Hornblende occurs in flows close to the supracrustal-granitic rock contact but actinolite, probably associated with chlorite, is found towards the centre of the greenstone belt. Mafic clastic rocks, either tuff

or arenite, are also composed predominantly of plagioclase and an amphibole, but contain variable proportions of biotite and sphene. It is probable that biotite represents original clay-mineral content and that sphene and leucoxene are secondary alteration products after titaniferous opaque minerals. No clast boundaries were observed in these rocks, suggesting that original grains were small, either ash or fine sand-size. Compositional banding, which is ubiquitous in the mafic clastic rocks, is undoubtedly primary and was probably developed by sorting prior to lithification.

Intermediate to felsic metavolcanics typically contain plagioclase and quartz commonly as clasts or phenocrysts in a finer plagioclase-quartz matrix. In felsic metavolcanics, the only other essential component is sericite, a white mica. Intermediate to felsic metavolcanics contain biotite with or without sericite. Clastic metasediments are also characterized by a predominance of feldspar, quartz, biotite, and sericite but commonly contain chlorite, sphene and leucoxene, amphiboles or tourmaline, or, rarely, garnet, chloritoid, or andalusite.

In all of the supracrustal rocks, plagioclase crystals are commonly twinned, euhedral, and partly altered to saussurite, and are closely associated with fine intergranular epidote. Amphiboles, especially hornblende, are generally poikilitic and enclose fine grains of plagioclase.

Due to alteration and fine grain-sizes, the anorthite content of plagioclase crystals in mafic flows is commonly difficult or impossible to determine in thin section. As noted by H.G.F. Winkler (1976), the anorthite content of basalt and andesite may vary from An_{70} to An_{45}, thus, although some plagioclase compositions may be obtained, it would be difficult to correlate them with grade of metamorphism without further knowledge of original anorthite contents.

The presence of actinolite, probably associated with chlorite, in mafic rocks in the central part of the supracrustal belt indicates that these rocks were transformed, according to the classification of Winkler (1976), at the low-temperature part of low-grade metamorphism. The absence of chlorite and the presence of hornblende in mafic rocks close to the supracrustal-granitic rock contact indicate the medium-grade metamorphism. In the same area, the persistence of garnet, chloritoid, and andalusite, and the absence of staurolite and cordierite in pelitic rocks indicate the high-temperature part of low-grade metamorphism. The stability of these minerals in pelitic rocks is, however, dependent upon bulk composition and, as indicated by mineral parageneses, it is possible that the supracrustal rocks around the edges of the greenstone belt were subjected to the low-temperature part of medium-grade metamorphism.

METALLOGENESIS

The occurrence of gold and molybdenite seem closely related to the proximity of granitic rocks. Gold and molybdenum may have been concentrated and deposited by hydrothermal fluids during the partial remelting and remobilization of the granitic lithosphere beneath the supracrustal sequence.

No evidence was obtained to suggest why pentlandite, galena, and sphalerite have only been found along the northern half of the greenstone belt, most notably at Wigwam Lake. It is evident that pyrite, pyrrhotite, and chalcopyrite, and, to a lesser extent, arsenopyrite, were carried in hydrothermal fluids which produced alteration in fault zones throughout the belt. Although gold is not reported closely associated with arsenopyrite, it does appear to be associated with sulphide mineralization.

It may be significant that the Twin Gold Mines Limited property is located close to the termination of the syncline centred on Seeber Lake, an area which was probably a sedimentary basin during the late stages of the development of the Lingman Lake belt. Fluids could have concentrated gold in the subsiding basin and then migrated upward but parallel to the axis of the fold, eventually depositing the gold at the termination of the syncline. The only other gold occurrence reported in the Lingman Lake belt was found on the north limb of the Seeber Lake syncline.

All of the important occurrences, other than those of molybdenite, have been found in the vicinity of the syncline at Seeber Lake. Such a distribution of known occurrences could be the result of more intense faulting and mineralization across this part of the belt; it could be related to the concentration and redeposition of metals in the Seeber Lake sedimentary basin or it may simply be a result of more intense exploration in rocks which were previously thought to be on strike with the Twin Gold Mines Limited property.

Suggestions for Further Exploration

Sulphide mineralization is widespread throughout the Lingman Lake belt. Sulphide minerals related to volcanism have not been observed or reported, however the most probable locus for volcanogenic massive sulphide deposits, the felsic and intermediate to felsic metavolcanics along the south ends of Seeber Lake and P.S. Lake and at Tequila Lake, have never been extensively explored. Unexposed felsic metavolcanics could also parallel the syncline centred on Durrel Lake.

Molybdenite appears to be closely associated with the contact between the supracrustal and granitic rocks and exploration activities would best be concentrated along this contact. Although all of the occurrences noted are within the supracrustal rocks, the granitic rocks have probably not been carefully examined and there is no apparent reason why molybdenum-bearing solutions could not have cooled within the granitic rocks.

Exploration for base metals might best be restricted to fault zones in the vicinity of Seeber Lake. There is no known evidence to preclude economic occurrences in other less heavily explored areas. Arsenopyrite, chalcopyrite, galena, pentlandite, and sphalerite may occur in any fault zone within the supracrustal and granitic rocks in the Lingman Lake region.

The association of gold with the supracrustal-granitic contact suggests that hydrothermal gold-bearing fluids could have originated in the granitic rocks and that gold is most likely to be found in the vicinity of the contact. Much of this contact has not been intensely explored. Alternatively, the association of gold with sulphide mineralization suggests that gold-bearing fluids originated at depth and that gold may have been deposited anywhere within or possibly outside the greenstone belt. Exploration may thus be carried out in any faulted zone in the region. It may be possible, however, that such fluids only deposited gold in the metavolcanics where they were intruded by the granitic rocks. Again, the contact of the metavolcanics with the granitic rocks becomes a prime exploration target.

The association of gold with the syncline centred on Seeber Lake suggests that gold-bearing fluids could have originated in the Seeber Lake sedimentary basin and that gold may only be found in the vicinity of Seeber Lake, thus indicating that the exploration for gold might best be restricted to this region.

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